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From the Editor's Desk

Nepal Engineering College (nec) and the SCITECH Nepal Journal have seen the ups and downs in their twenty-four years long journey through the good and bad times; both are highly resilient. Initiated with a humble purpose to provide a platform for the Nepalese academicians to publish their experiences, the SCITECH Nepal has evolved into a respectable journal in science and technology; the quality of the papers in this issue vouches for it. The long and sleepless hours spent on researches and synthesizing the outputs in a few pages in a daunting task, yet the researchers do it out of a sheer joy of mutual sharing of knowledge; this constant process of knowledge generation and sharing underlies the rise in physical comfort in life. Nepal Engineering College strives to continue in its path, with the cooperation from all its well-wishers.

We are extremely pleased to bring out this issue of SCITECH Nepal, after a short hibernation, which resulted, in part, from the misunderstanding on the mission and vision of Nepal Engineering College on the part of some of the founders of the College. Now that the College has taken a clear path to the continued growth of science and technology, with the ultimate aim of contributing to the national development through imparting quality education to the students, providing adequate space to the college staff for their professional development, and collaborating with research institutes, the continued path to better knowledge management is ensured.

On behalf of the editors, I would like to express appreciation to the authors and evaluators of the papers for your contribution to keep the spirit of the generation and management of scientific knowledge ongoing. Our next step should be to enhance the necessary skill to apply the knowledge for a better life of the people in general.

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Factors Affecting Project Based Learning Intention of Engineering Students



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Abstract

The factors affecting the project-based learning intention (PjBLI) of engineering students have been studied using theory of planned behaviour (TPB). Descriptive study was carried out utilising quantitative technique. Primary data were collected through cross sectional survey, utilizing seven point Likert scaled questionnaire. The respondents were final year students of Nepal Engineering College. Statistical tool (SPSS) was used for analysis. The result shows that the levels of both the PjBLI and the attitude of students (ATTI) towards project-based learning (PjBL) are high followed by the level of perceived behavioural control (BC). However, the level of subjective norm (SN) is relatively lower. There are no significant differences in PjBLI, ATTI, SN and BC among students from different departments. However the BC (perception of self efficacy or capability) of female students is higher than that of male students. Regression analysis shows that 42.2 and 19.3 percentages of PjBLI are affected by SN and ATTI respectively. The study concludes that additional effort is essential to improve SN (support from project supervisor, department and colleague) which in turn helps to improve PjBLI of students and their performance.

Keywords— *project-based learning, intention, attitude, regression, academic performance*

I. Introduction

In a study, Shakya (2011) found 21 percent of engineering graduates in Nepal unemployed while 77 percent unsatisfied with their job due to low pay and poor working environment [10]. Hands on experience and exposure to real work environment are essential qualifications for engineering students to become competent for getting jobs once they enter into job market. Project-based learning (PjBL), in one way or the other, helps students getting hands on experience while they execute project work. Therefore, the PjBL contributes to address unemployment problem for engineers. The PjBL initiated with collaboration between education and industrial sectors will provide greater exposure to real work environment and hands on experience. Such initiative motivates students towards (PjBL) and improves their overall performance. Thus PjBL not only improves students' overall performance but also helps them to become competent in the job market.

The scope of study is confined to the Nepal Engineering College as it is the first not-for-profit social academic institute, and the largest engineering college affiliated to the Pokhara University. The students enrolled at this college are from diversified cultures and geographical locations; and therefore, they are considered representative samples of bachelor level students in Nepal.

Project based learning approach (PjBL) has been adopted in Nepal Engineering College and projects are assigned to the final year students as a credit course in addition to small projects assigned during each semester. The effectiveness of the PjBL depends upon the intention and attitude of students towards the PjBL. According to theory of planned behaviour behavioural intention is affected by three factors namely attitude towards the behaviour, subjective norms and perceived behavioural control [4]. The study on the effectiveness of the present project based learning approach is important to identify the need for any modifications of existing approach. In this context, this study has analysed the factors affecting the project-based learning intention (PjBLI) utilizing theory of planned behaviour (TPB).

The prevalent tendency of engineering students giving less time to the project work can be attributed either to the compact curriculum for which they have to give more time for other subjects or to their poor attitude and intention towards the project work. According to Karaman and Celik (2008) and ChanLin (2008) the learners in project-based learning (PjBL) perform better in skill development, general ability and knowledge compilation than those who do not use project-based learning [11][8]. These findings indicate the importance of PjBL for student to improve their skill, knowledge and the overall performance. The tendency of students giving less time for project work, if not investigated and corrected on time may lead to continuous poor performance of students in terms of knowledge and skill development. This is the educational issue which need immediate attention. In the context of this problem following research questions are raised.

- To what extent students' attitude (ATTI), subjective norm (SN) and perceived behavioural control (BC) affect their project-based learning intention (PjBLI).

- How PjBLI, ATTI, SN and BC differ between students from two different departments.
- How PjBL, ATTI, SN and BC differ between the male and female students

II. Literature review

Project-based learning (PjBL) improves students' positive learning attitude towards technology (Mioduser and Betzer, 2007; Tseng, Chang, Lou and Chen, 2011)[2][6]. According to Thomas (2000), the PjBL is an active learning practice in which students acquire necessary knowledge while resolving problems that appear in the project; whereas traditional passive learners only receive second hand knowledge [5]. However the effectiveness of PjBL, according to Thomas (2000), depends upon the materials of PjBL, the extent to which the project is relevant to the level of the learners, the complexity of the project, provision of appropriate support, the learners' prior knowledge and teamwork skills [5]. These literatures show that PjBL is affected by attitude of the learners, support they get, teamwork and their perception about their self efficacy or capability for performing the project. The theory of planned behaviour (TPB) has been successfully utilized in the studies (Linan & Chen, 2006, McStay, 2008) similar to the present study to describe the factors affecting human intention and behaviour [3][1].

According to the theory of planned behaviour (Ajzen, 2015), human behaviour is guided by three kinds of considerations: beliefs about the likely consequences or other attributes of the behaviour (behavioural beliefs), beliefs about the normative expectations of other people (normative beliefs), and beliefs about the presence of factors that may further or hinder performance of the behaviour (control beliefs) [4]. In their respective aggregates, behavioural beliefs produce a favourable or unfavourable attitude toward the behaviour; normative beliefs result in perceived social pressure or subjective norm; and control beliefs give rise to perceived behavioural control, the perceived ease or difficulty of performing the behaviour. In combination, attitude toward the behaviour, subjective norm, and perception of behavioural control lead to the formation of a behavioural intention. The model representing the theory of planned behaviour is presented in figure 1.

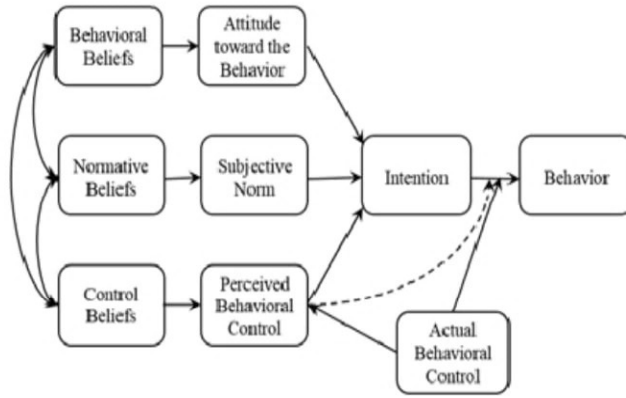


Fig. 1 A model showing theory of planned behaviour (Ajzen, 2015)

In the present study the PjBLI represents students' project-based learning intention which is considered as dependent variable. Students' attitude towards project-based learning practice is represented by ATTI, The aggregate of the support from department, supervising teachers and colleague is represented by SN, and the perception of students about their self efficacy or capability to perform the project is represented by BC. The variables ATTI, SN and BC are considered as independent variables. The theoretical framework for the present study is presented in figure 2 and the definition of dependent and independent variable is presented in the table I

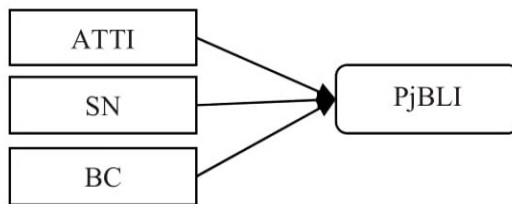


Fig. 2 A model showing theoretical framework

TABLE I
Definition of variables

Variables	TPB Model	Model for Present Study
Dependent	Intention	PjBLI
Independent	Attitude towards the behaviour	ATTI
	Subjective Norm	SN
	Perceive Behavioural Control	BC

In a study, Tseng et al. (2011) analysed the effectiveness of the PjBL in the four different subjects named as science, technology, engineering and mathematics; and found the PjBL most effective in case of engineering subject followed by science and then technology while mathematics being least affected [6]. This finding suggests that the effectiveness of PjBL differs with the type of subjects or courses in which it is applied. Therefore, a hypothesis is drawn and the null hypothesis is set as:

Null hypothesis (H1): There is no significant difference between students from two departments in terms of their intention (PjBLI), attitude (ATTI), support (SN) and perceived self-efficacy (BC).

In another study conducted to find the effectiveness of PjBL applied to mathematics for high school students in South Australia, Rajkin (2017) found differential effectiveness of PjBL for males and females with female preferring traditional method over PjBL and males finding PjBL enjoyable and beneficial [9]. This finding suggests that the effectiveness of PjBL differs between male and female students. Therefore, another hypothesis is set as:

Null hypothesis (H2): There is no significant difference between male and female students in terms of intention (PjBLI), attitude (ATTI), support (SN) and perceived self-efficacy (BC).

III. Methodology

A. Research Design

The field-based survey research, cross sectional in nature is selected for this study. The data was collected through sample survey at one point in time utilizing questionnaire. The respondents are the final year students studying in Nepal Engineering College. The data are numeric and they can be statistically operated. Therefore, quantitative research design is utilized for this study which quantifies and generalizes results from the sample to population.

The questionnaires designed for seven point Likert scale are utilized to obtain responses from respondents to examine the factors that affect students' project-based learning intention (PjBLI). The tested questions,

used for similar kind of studies, are modified and contextualized. The questionnaires can be found online at <https://bit.ly/2OJoLli>.

B. Data Collection

The samples were randomly selected from each department. The final year students are selected as the respondents because they are assigned with the whole day project work during their final year study.

Ten sets for questionnaire were provided in paper for each department and students are also asked to respond through Google-form. The responding students are randomly selected randomizing their college roll numbers. Only 72 students responded within the time frame. Since there are a minimum of three questions for data collection for each construct (variable), the effective sample size becomes 216.

There were 400 hundred final year students at the time of survey, and the number is the sampling frame for this study. The minimum required sample is calculated using formula (1) suggested by Yamane (1973), and found to be 80 with 10% error.

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

where :

N = sampling frame = 400

e = allowable error = 0.1

The number of sample 216 is well above the minimum required number 80, and therefore the samples are sufficient for this study.

C. Reliability and Validity

Reliability is ensured through Cronbach's alpha assessment of internal consistency of the questionnaire used for measurement of each construct. The alpha values are found as 0.75, 0.73, 0.6 and 0.6 for the construct SN, ATTI, PjBLI and BC respectively. The alpha value above 0.6 is sufficient to ensure internal consistency of indicators used to measure human behaviour (Cohen et al., 2007)[7].

According to Cohen et al. (2007), validity is a matter of degree of an instrument that in fact measure what it seeks to measure[7]. The questionnaire had been used successfully in similar kind of previous

studies (Linan and Chen, 2006; McStay, 2008) to measure human intention and behaviour [3][1]. Those questionnaires are adapted and contextualized for this study to ensure validity.

D. Analysis

Normality of data distribution is ensured through skewness and kurtosis of the data distribution. The data distribution having both skewness and kurtosis within the range from -2 to +2 is considered normal enough for performing parametric tests. The table II shows that values are within the range for all data distribution: PjBLI, ATTI, SN and BC. Therefore the parametric tests including t-test and multiple regressions are used for data analysis. The figure 3 shows histogram showing normality of data distribution of the variable BC.

TABLE II
Measure of Normality of data distribution

	PjBLI	ATTI	SN	BC
Skewness	-1.098	-1.222	-1.135	-.930
Kurtosis	.716	.862	1.403	.249

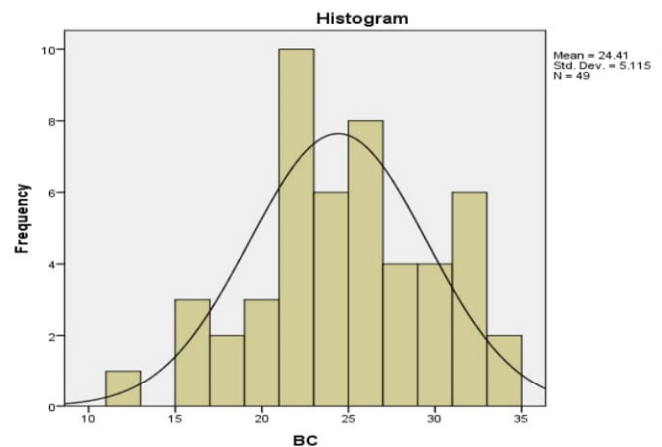


Fig. 3. A histogram showing normality of data distribution

When two questions or scales used to measure the same construct are highly correlated then the question becomes redundant. Collinearity of the scales used for this study is checked using SPSS statistical tool. The variance inflation factor (VIF) for each case is found to be less than 2. The VIF less than 3 is considered sufficient to ensure that the scales are not collinear.

Independent sample t-test is used to test the hypotheses at 95 percent confidence level, and multiple regression analysis is carried out to test the effect of

independent variable (IV) on dependent variable. The equation 2 shows the regression equation utilised for this study.

$$PjBLI = \text{Constant} + B1(ATTI) + B2(SN) + B3(BC) \quad (2)$$

where,

B1, B2 and B3 are beta coefficients

PjBLI is the project based learning intention,

ATTI is the attitude towards PjBL,

SN is the subjective norm, and

BC is the perceived behavioural control

E. Ethical Consideration

This study has considered all ethical components (Cohen et al., 2007) right from the beginning data collection procedure to the preparation of final report [7]. Due consideration was given for avoiding offensive, discriminatory or other unacceptable words and language in questionnaires which may harm the dignity of respondent. The responses they provide are used only for the purpose of study. Confidentiality, respondents' right to privacy, personal matter or sensitivity of information is preserved in many ways; for example, the respondents' responses are coded and the statistical results are drawn from the total sample. Not, a single student is brought under a separate analysis.

In the process of data analysis, the statistical techniques that were used by the previous researchers and validated by statisticians are utilised. Acknowledgement of works of other authors used in this dissertation, the honesty in data processing, use of references materials, are also considered for this research.

IV. Results

The descriptive statistics shows that the level of the attitude (ATTI) of the students towards the project-based learning (PjBL) is the highest (94.1%) followed by the level (93.7%) of PjPLI intention. However, the level of SN is the lowest (77.6%). These figures indicate that the students have high level of readiness and high positive attitude towards project-based learning approach. The percentage scores are presented

in the table III.

TABLE III
Level of Variables in Percentage

Variables	Score Percentage	Std. Deviation
PjBLI	93.7	1.491
ATTI	94.1	1.548
SN	77.6	6.058
BC	82.3	2.541

Independent sample t-test shows that there is no significant difference between students from any two different departments in terms of their PjBLI, ATTI, SN and BC. The result of the independent sample t-test at 95 % confidence level between the students from the architecture and electrical department is presented in the table IV. The t-test results show that the p-values are 0.475, 0.451, 0.689 and 0.384 for the data distribution of the variables PjBLI, ATTI, SN and BC respectively. The p-value for each of the data distribution is greater than 0.05. The t-test was repeated between architecture and each one of other departments. The p-value in each case is found to be greater than 0.05. Therefore, null hypothesis is accepted; which mean that there is no significant difference between students from any two departments in terms of PjBLI, ATTI, SN and BC. In another word, students' intention and attitude towards PjBL are similar in all departments; and there are no significant differences between the students from any two departments in terms of the level of support they get and their perception about their capability for performing the project work.

The result differs with the result of the previous study (Tseng, 2013) in which the effectiveness of PjBL differs among four subjects named as science, technology, engineering and mathematics (STEM) [6]. The difference can be attributed to the fact that the respondents in the present study are all engineering students though they are from different departments. However, Tseng (2013) analysed the effectiveness of PjBL applied to four different subjects named as STEM for the same group of students [6].

TABLE IV

Independent sample t-test between sample students from electrical and architecture departments

Variables		Levene's Test for Equality of Variance		t- Test for Equality of Means
		F	Sig.	Sig. (2-tailed)
PjBLI	Equal variances not assumed	.000	.994	.475
ATTI	Equal variances assumed	2.816	.105	.451
SN	Equal variances assumed	17.914	.000	.689
BC	Equal variances assumed	2.216	.148	.384

Another independent sample t-test shows that there is no significant difference between male and female students in terms of PjBLI, ATTI, and SN. However, they are significantly different in terms of BC. In another words female student's perception about their capability is better than that of the male students though their intention and attitude towards the PjBL are similar. The results are presented in the table V. The p-value in case of data distribution of variable SN is below 0.05. Therefore the null hypothesis is rejected and alternate hypothesis is accepted which means that there is significant difference between male and female students in terms of BC.

The descriptive statistic shows that the mean score of female students in terms of BC is higher than that of male students, which means they perceive their capability higher than that of their male colleague. However, the p-value for each of the data distribution of variable PjBLI, ATTI and SN is greater than 0.05. Therefore, null hypothesis is accepted for each of those data distribution, which means that there is no significant difference between male and female students in terms of PjBLI, ATTI and SN.

TABLE V

Independent sample t-test between male and female students

Variables		Levene's Test for Equality of Variances		t-test for Equality of Means
		F	Sig.	Sig. (2-tailed)
PjBLI	Equal variances assumed	.079	.781	.708
ATTI	Equal variances assumed	1.142	.291	.653
SN	Equal variances assumed	2.403	.128	.459
BC	Equal variances assumed	3.296	.076	.028

The cause and effect relationship between the dependent variable (PjBLI) and the three independent variables (ATTI, SN and BC) is obtained utilizing multiple regression analysis. The regression equation is presented as equation (3). The beta coefficients for the equation are presented in the table VI.

$$PjBLI = 12.65 + 0.195 ATT + 0.422 SN - 0.003 BC \quad (3)$$

where,

PjBLI is the project based learning intention,

ATT is the attitude towards PjBL,

SN is the subjective norm, and

BC is the perceived behavioural control

TABLE VI

Beta coefficients of multiple regression equation

Model	Constant/ Variables	Unstandardized Coefficients		Standardized Coefficients
		B	Std. Error	Beta
1	(Constant)	12.650	3.024	
	ATTI	0.186	0.129	0.193
	SN	0.104	0.033	0.422
	BC	-0.002	0.080	-0.003
Dependent Variable: PjBLI				

The equation (3) shows that any one unit of variation in SN will cause 42.2 percent variation in PjBLI when other variables are kept constant. Similarly, the effect of ATT on PjBLI is 19.5 percent. However, the effect of BC on PjBLI is negligibly low. This results indicate the effect of SN on PjBLI is the highest followed by that of ATT. In another words any small additional support in terms of equipment and facilities from the concerned department, proactive inquiry from project supervisor, and active involvement of project group members together will significantly improve the PjBL intention of students. Additional support (SN) from department, teachers and friends also increase the positive attitude (ATT) of students. In that case, the aggregate affect of both SN and ATT on PjBLI will be even higher than the individual effect of SN.

V. Conclusions And Recommendation

The level of support from concerned department, supervising teachers and project partners or colleague together is measured by the variable called subjective norm (SN); and the students' attitude towards project based learning (PjBL) is measured by the variable called attitude (ATTI). One unit changes in the level of SN and ATTI affects 42.2 and 19.3 percent changes in the students' project-based learning intention (PjBLI). The SN also has indirect positive effect on ATTI; which mean that improvement in SN has multiplying positive effect on PjBLI. Therefore, the study concludes that any additional small effort to improve SN (support from project supervisor, department and colleague) significantly improves PjBLI of students and their performance.

The students in architecture department normally execute project work larger in numbers than the students do in other departments. The independent sample t-test shows that there is no significant difference between the students from architecture and electrical department in terms of PjBLI at 95 percent confidence level. With this finding, it is concluded that PjBLI is not affected by the number of project. In other words, increasing the number of project does not improve students' intention.

With the significant differences between male and female students in terms of behavioural control BC, the study concludes that female students perceive that they are more capable in performing the project in

comparison to the perception of male students about their capability or self-efficacy.

The result of a quantitative study is better interpreted when the result is compared and correlated with the interviews collected during a qualitative study. Human attitude and behaviour are better interpreted with mixed method research in which both quantitative and qualitative approaches are utilized. The author recommends for a qualitative study in future based on the present quantitative study in order to explain in depth why engineering students showing such intention and behaviour. Moreover, further research with respondents from all other engineering colleges is also recommended for generalizing the findings to a larger population.

Acknowledgment

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Scenario Based Requirement Engineering (SBRE) in eXtreme Programming (XP) through Agile Modelling (AM)



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Abstract

Software development methodologies have been enhancing significantly all the time and have drawn the attention of software professionals from past few years. The software development methodologies are expanding rigorously with wide range of diverse fields and have become more complex demanding the agility to rapidly changing needs of the customers. As a result, agile software development methodologies have evolved and gaining popularity day by day. Agile software development methodologies have come up with modifications demanded in traditional software development process to make them faster, more flexible, light weighted and productive. Extreme Programming (XP) is one of the well-known agile software development methodologies and is driven by a set of values including simplicity, communication, feedback and courage. Planning game, very short release stories and test first coding are some interesting extreme practices of XP; however it is criticized for some deficiencies like light weight requirement, onsite customer, pair programming and so on. The study has only focused on only one of the most criticized extreme practice-lightweight requirement and has followed agile modelling approach to make improvement on requirement engineering process in XP. Requirements are the user stories that consist of a few sentences (1-3 sentences) written on an index card which describes the functionality given by single onsite customer in XP. There is lack of analysis of stakeholders and their roles in requirement process. Therefore, it is very difficult to know the specific requirements of the specific stakeholder in XP. This means that the requirement engineering process is incomplete in XP. This may result high chances of providing deficient requirements. Agile Modelling (AM) is the chaotic practice based methodology for effective modelling. The interesting part of AM is that it does not tell how to model, but tells about how to be effective as modellers. A Scenario Based Requirement Engineering (SBRE) is proposed using AM as alternative to light weighted requirement which one of the most criticized extreme practice of XP. SBRE is the implemented description of techniques that helps to understand the task related activities and also facilitates communication among stakeholders and experts. Stakeholders are analysed for understanding a system by identifying the stakeholders in the system, and assessing their respective requirements and influence on the system. This will help to get better requirements for system development, but still needs to be validated.

[Keywords]—Agile, eXtreme Programming (XP), Agile Modelling (AM), pair programming, onsite customer, Scenario Based Requirement Engineering (SBRE)]

I. Introduction

Software development methodologies are the frameworks that are used for structuring, planning and controlling the processes involved in software development. Waterfall model, V shaped model and Rational Unified Process (RUP) are the most popular traditional software development methodologies. These methodologies involve sequential series of steps that need to be planned and documented in detail before implementation and are very rigid to change that will be occurring in future. As a result, plan driven heavyweight traditional methodologies have transformed into agile software development methodologies to address the rapidly changing requirements of the market. Agile software development methodologies are developed with the ability to respond quickly with changing requirement [1]. Therefore, it is not simply the size of the process or the speed of delivery; it is about the flexibility of the process or methods [2]. Agile methodologies include modification in software development process to make them faster, more flexible, light weighted and productive. In the late 1990s, several software development methodologies drew the attention of the public and each method has a combination of old ideas, new ideas and transmuted old ideas [3]. The common among all these methodologies was that they all emphasized personal interaction over process, direct communication, short and frequent release, iterative process, self-organization and code crafting among others. Extreme Programming (XP), Scrum, Feature Driven Development (FDD), Crystal Methodologies Family (CMF) and Adaptive Software Development (ASD) are the most popular agile methodologies in use today. XP and Scrum are the most commonly used agile software development methodologies in software industry. One of the well-known methods of Agile is extreme programming (XP in short) and is driven by a set of values including simplicity, communication, feedback and courage and is characterized by a short development life cycle, incremental planning, continuous feedback and reliance on communication and evolutionary design and is characterized by some extreme practices such as planning game, small releases, metaphor, simple design, test driven development (TDD), refactoring, Pair Programming (PP), collective ownership, continuous integration,

40-hour week, onsite customer and coding standards [4]. XP was developed by Beck and Jeffries with interesting composition to improve the quality of software development process as well as to respond the changing need of customer [3]. XP is known to be a lightweight agile software development methodology with some extreme practices which are lightweight in nature but very difficult and sometimes unrealistic to implement and there are only a few analytical studies on XP. Most of the literature and books have been drafted by the inventors of the Agile Manifesto and are concerned with the promotion and commercialization of the agile methods and the services they provide. Figure 1 shows the general overviews of XP. Release planning is done with the help of system metaphor obtained architectural spikes and the requirement specifications obtained from user story. Release plan helps to carry out the iteration which in turn produces a piece of software. Small releases are released after the acceptance test approved by customer.

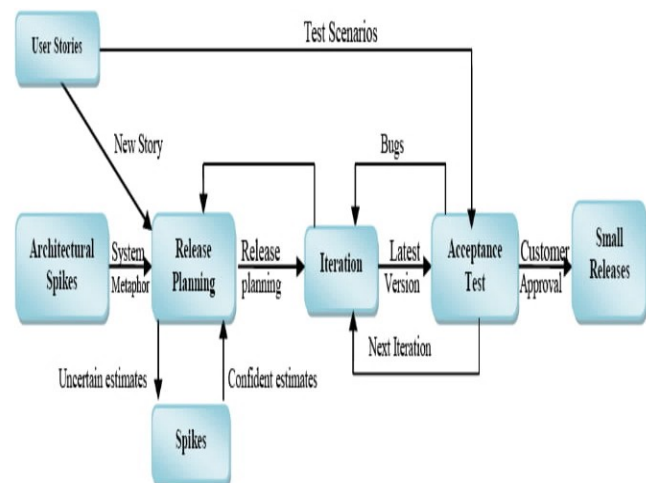


Fig 1. eXtreme Programming (XP) Release Cycle [5]

Extreme Programming is used as research framework to examine the chances of deficient requirements in XP. An interpretive approach is followed to conduct the literature review and this approach is concerned with the hermeneutic cycle derived from document and literary analysis. The hermeneutic cycle is used for the modelling of extreme programming regarding the most criticized practice-user story of XP. User story is criticised as lightweight

requirement with high chances of acquiring deficient requirement that propagates throughout the software development process. Interpretive approach was used to propose Scenario Based Requirement Engineering (SBRE) practice using agile modelling to address the chances of deficient requirements to make it realistic and practical. SBRE describes the implemented techniques that aid to understand and communicate the task related activities among stakeholders and experts.

II. Research Methodology

The aim of this study is to gain a thorough understanding of requirement process in extreme programming and to build the agile models of extreme practices addressing the pitfalls in requirement process that best suits for XP. The work is more concerned with the applicability of requirement engineering in XP and is considered XP requirement process as an initial research framework for explaining and evaluating various aspects of it. An interpretive approach was followed to conduct a literature review. A research can be interpretive if it builds on the assumptions that humans learn about the reality from the meanings they assign to social phenomena such as language, consciousness, shared experiences, publications, tools, and other artefacts [5]. The most fundamental principle of the interactive research approach is a hermeneutic cycle derived from documents and literary analysis. The different components of the hermeneutic cycle are illustrated in Figure 2. The first component of the hermeneutic cycle is concerned with the pre-understanding of researchers on the subject matter and the second component is concerned with the absorption of more knowledge from different sources to widen knowledge to expand the researcher's interpretation potential. The third component is concerned with theory building on the basis of an interpretation of knowledge, explanation attempts and missing knowledge. The last component is concerned with documenting the new theories and knowledge acquired through interpretive research approach [3]. The same approach of the hermeneutic cycle is used for agile modelling. The common purpose of modelling is to provide a basis for deeper understanding with experiments, predicting the behaviour of the system and saving the cost of actual case controlled experiments.

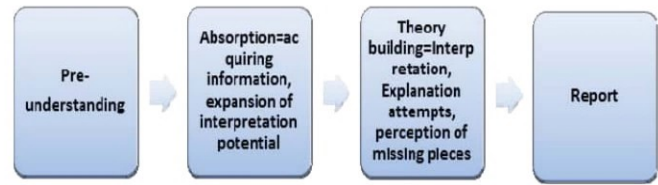


Fig 2. Hermeneutic Cycle [3]

III. Agile Modelling (AM)

Agile Modeling (AM) is the chaordic, practice based methodology for effective modeling and documenting software based systems [6]. It does not tell about how to build the model, but it tells about how to be effective as modelers. In other word it is not prescriptive process. It is a chaordic because it blends the chaos of simple modeling practices and blends it with the order inherent of software modeling artifacts.

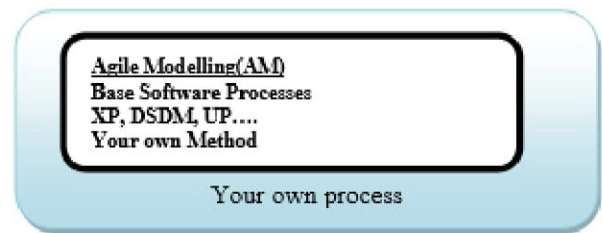


Fig. 3 Agile Modelling and Base Software Process [6]

Figure 3 shows the base software processes such as XP, Scrum, UP or your own personal process which can be tailored with AM. The best part of the AM is that it is possible to pick the best features from different existing software process and can be modelled it using AM to make your own process according to your need. AM is independent of other processes such as XP or UP, but it plays a significant role in enhancing those processes. Any person who follows the agile methodology applying the AM practices with its principle and values are agile modellers. An agile developer is who follows the agile approach to software development. Therefore, agile modellers are agile developers but not all the agile developers are agile modellers.

IV. Requirement Engineering in XP

XP is a lightweight agile methodology with four core values: simplicity, communication, feedback and courage [4]. Although XP has many interesting practices such as planning game, very short releases and test first coding among others, it is not free of critics. One of the most criticized practices in XP is light weighted requirement. Requirement engineering is the process of specifying requirements by studying stakeholder needs and the process of analyzing and refining those specifications systematically [7]. Specifications are the concise and clear statements that serve as a requirement that the software should satisfy. Requirement engineering must include four activities: elicitation, modeling, validation, and verification to produce clear and faultless requirements. Unclear and deficient requirement is one of the biggest causes of software failure. The process to acquire requirements in XP is different from the traditional methodologies. In XP, requirements are the user stories that consist of a few sentences (1-3 sentences) written on an index card which describes the functionalities of the customers' values. It serves as the starting point for developers and customers generate more precise detail [10]. And then the developer decomposes the user story on a card into manageable chunks of tasks recording each task and its status on the card. As there is no analysis of stakeholders and their roles in requirement process, it is very difficult to know the specific requirements of the specific stakeholder.

Information about the requirements of the whole system by a single onsite customer may lead unclear and deficient requirements because single customer does not know all the requirements of the concerned stakeholders. A stakeholder is defined as any group or individual who can affect or is affected by the achievement of the organization's objectives. One of the best solutions to avoid unclear and deficient requirement is to collect use scenarios and perform stakeholder analysis. A use scenario is the implemented description of techniques that helps to understand the task related activities and also facilitates communication among stakeholders and experts. Stakeholder analysis is an approach for understanding a system by identifying the stakeholders in the system, and assessing their respective interests in, or influence on the system.

Another big problem in XP requirement is that the customer wishes high expectations exaggerating the computer capacity and proposes the more functionalities request and hope that the developers deliver the product in very short time. This usually happens if the customer is unknown about the new technology and available platforms for development. Another major problem in XP is paying less attention towards the changing requirements which leads to project stagnation, modification on finished work and even abandon the finished work [8].

Modifications to the XP requirements process are reported by many researches and studies. There are various solutions suggested by different studies. But, most of the suggestions are based on the comparative studies. Scenario Based Requirement Engineering (SBRE) practice is proposed in this study.

V. Addressing Light Weighted Requirement in XP through Agile Modelling

Why Agile Modeling approach was used in modeling XP? The answer is very simple; Agile Modeling is a part of XP. It uses many Agile Modeling techniques such as User story, Component Responsibility Collaborator (CRC) cards, models and sketches. There are mainly two primary purposes for using modeling approach. First is to understand and make others understand what is being built and what are the processes involved in it. Second is to analyze the requirement and present detail design of the system. This work is concerned with both of the primary purposes of using modeling approaches. Agile Modeling is used for clarifying the necessity and analyzing them in term of agile models. Agile Modeling approach is used for requirement modeling to make the process realistic and practical in real XP project.

Requirements play significant role to make any project successful. However, unclear and deficient requirements in software development often lead to disappointment with an unreliable product which may even results dangerous accidents. Therefore, with unclear and deficient requirements create more problems than they solve. One of the major determining factors to make the software development organization successful is how well they understand and manage their requirements. Requirement engineering is the process of developing requirements through an iterative cooperative process of analyzing the problems,

documenting the resulting observations in a variety of representation formats and checking the accuracy of the understanding gained [9].

To get clear and adequate requirements, collection of use scenarios is proposed in this study. Use scenarios can be defined as the implemented description of techniques that helps to understand the task related activities and also facilitates communication among stakeholders and experts. The effectiveness of using scenarios in several subjects can work as the capability of simulating thinking. In simple words, scenarios are the representation of the real world and can be generalized for requirement analysis to produce the required models which are familiar to requirement engineers or software engineers. Figure 4 shows how requirement specifications are related to real world scenarios and how real world scenarios can be used for designing rational models and concept prototypes which helps to ex-tract real requirements from the real world. The best ways of obtaining requirement specifications from usage scenarios are inspection and observation which helps in brainstorming to get the real requirement of the project.

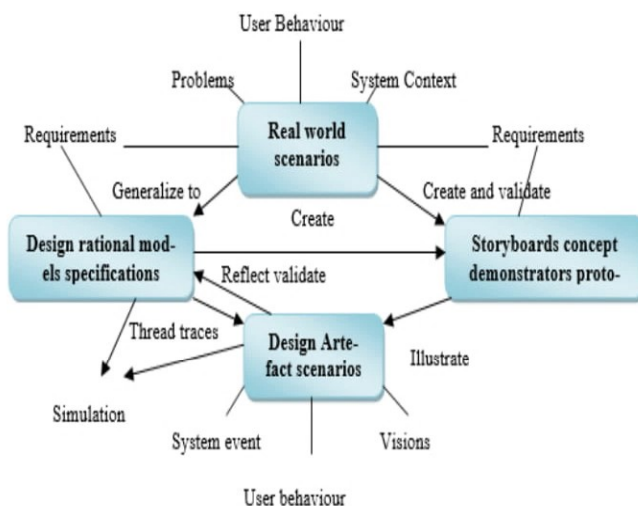


Fig. 4 Roles of scenarios and their relationship with requirements [10]

Real World Scenario is the real world of interest that is inspected or observed. Real worlds are always concerned with problems, behaviors and system context. Close inspection and observation helps in brainstorming to derive the real requirement specifications of the system. The real world scenarios

can be generalized to rational models with generalized specifications derived from real world scenarios. Storyboard-Concept demonstrator prototype is a story or example of real world events or grounded theory abstracted from real world experience. Designed Artifact Scenarios is the final designed artifact scenarios derived from the real world scenarios. It is the use case collected from the real world scenario and can be represented in a variety of formats. It can be sequences of use case diagrams or list of use case requirement specifications. There are two methods in scenario based requirement engineering, and they are ScenIC method and SCRAM method [11]. Scenic Method was proposed by Colin Potts in 1999 and it consists of goals, objective, task, actor and obstacle [12]. Scenarios are made up of episode and actions. Man or machine can be actor and goals can one of the following-achieving states, maintaining states or avoiding states. Obstacles show the successful completion of tasks. In this method, every cycle involves in criticism and inspection of the scenarios that helps to further refine the requirement specifications. General guidelines are provided to format scenario narratives and to identify goals, actions and obstacles. Goals are achieved in episodes and episodes are evaluated with goals achieved. Goals are achieved with the help of system tasks which are carried out by actors. Dependencies are examined among goals, actors, tasks and resources to make sure that all the requirements of the system are met [11]. SCRAM stands for Scenario Based Requirement Analysis and this method does not explicitly provide modelling and specification. It works in parallel with software engineering methodology chosen by the practitioner. It is used for requirement elicitation with reasoning about the problem extracted from scenario about use context [10]. It is usually done after preliminary design.

After requirements are collected from scenario based requirement engineering process, the next step is to identify the stakeholders and perform analysis. There are many approaches to identify the stakeholders. From the viewpoint of software and requirement engineering, following are the most appropriate stakeholders staked with the software end product and software development processes Fig 5.

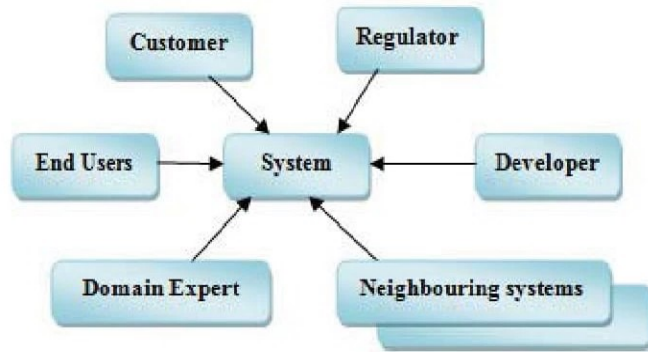


Fig. 5 Different types of stakeholders

Stakeholder analysis is a technique of understanding a system by identifying the stakeholders staked to the system and assessing their relationships, interests and expectation from the system or project. Following are the general steps of stakeholder analysis Fig. 6 [13].

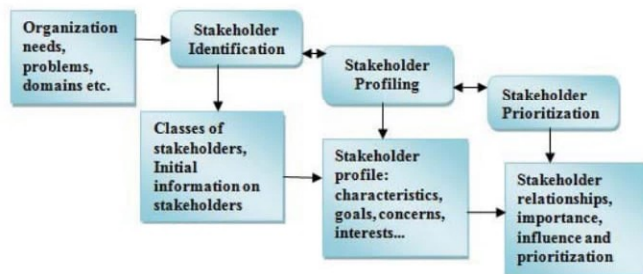


Fig. 6 Stakeholder analysis process [13]

All the above discussed changes are modelled in the release cycle of XP and are shown in Fig. 7. The requirement changes are carried out in three stages- collect user scenarios, stakeholder identification and analysis; and then only detail user e-story is prepared.

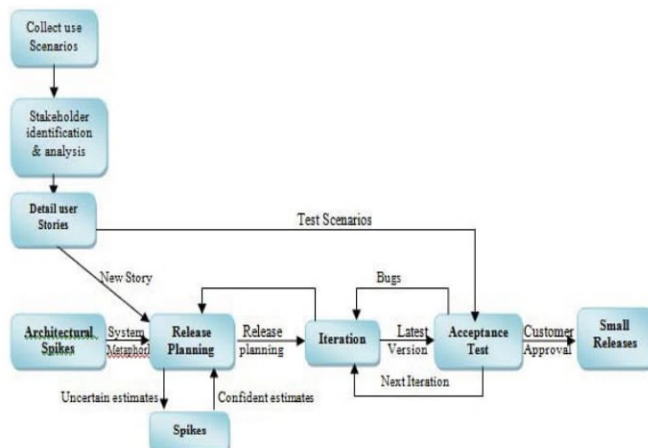


Fig. 7 Requirement model in release cycle

VI. Conclusions

Agile software development methodologies have been evolving continuously with the demanded improvements needed in traditional software development methodologies. Agile methodologies are characterized by personal interaction over process, direct communication, short and frequent release, iterative and incremental process, self-organization, code crafting and many more. Extreme Programming (XP) is one of the well-known agile software development methodologies with sets of values including simplicity, communication, feedback and courage. One of the most criticised lightweight processes introduced in XP is lightweight requirement (user story) which is taken as one of the extreme practice in XP. The extreme practices and composition variation has made the software development process more complex. Lightweight requirement is taken into consideration for the study and agile modelling for lightweight requirement was performed to overcome the pitfalls found during the study. The study concluded with requirements in XP can be improved with collecting use cases from scenario based requirement engineering practice followed with stakeholder analysis. Agile model needs to be validated which can be further studied in the future. The study concentrates on the most criticized practices-lightweight requirement of XP. In the future, further study about other extreme practices can be carried out to refine the practices and make them simple, practicable and applicable.

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Analysis of EEG signal of specific epileptic patient prior to its occurrence

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Abstract

Epilepsy is a neurological disorder of brain and the electroencephalogram (EEG) signals are commonly used to detect the epileptic seizures, the result of abnormal electrical activity in the brain. This paper is focussed on the analysis of EEG signal to detect the presence of the epileptic seizure prior to its occurrence. The result could aid the individual in the initiation of delay sensitive diagnostic, therapeutic and alerting procedures. The methodology involves the multi-resolution analysis (MRA) of the EEG signals of epileptic patient. MRA is carried out using discrete wavelet transform with daubechies 8 as the mother wavelet. For EEG data, the database of MIT-BIH of one of the patient with 41 different cases is used. The result showed that a unique pattern is observed during the spectral analysis of the signal over different bands with positive predictive value of 100%, negative predictive value of 82.35% and the overall accuracy of 85.37%. This unique pattern, basically energy burst in two of the bands of the signal can be used as important feature for the early detection of the epileptic seizure. All the results have been simulated within the Matlab environment.

Keywords – Electroencephalography, Epileptic seizure, Discrete wavelet transform, Daubechies 8.

I. Introduction

Electroencephalography (EEG) is the recording of electrical activity along the scalp. It measures voltage fluctuations resulting from ionic current flow within the neurons of the brain. In clinical context, it refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp [1]. The diagnostic applications generally focus on the spectral content of EEG, that is, the type of neural oscillations that can be observed in EEG signals.

The EEG signal contains several spectral components. The amplitude of a human surface EEG signal is in the range of 10 to 100 μV . The frequency range of the EEG has a fuzzy lower and upper limit, but the most important frequencies from the physiological viewpoint lie in the range of 0.1 to 30 Hz. The standard EEG clinical bands are the delta (0.1 to 3.5 Hz), theta (4 to 7.5 Hz), alpha (8 to 13 Hz), and beta (14 to 30 Hz) bands [2]. EEG signals with frequencies greater than 30 Hz are called gamma waves.

Epilepsy is a chronic neuronal disorder or group of disorders, characterized by the recurrent (two or more) seizures that usually recur unpredictably in the absence of provoking factors. It is linked to an abnormal and excessive discharge from a set of neurons in a specific locus of the brain. This clinical manifestation consists of sudden and transitory abnormal phenomena which may include alterations in consciousness, motor, sensory, autonomic or psychic behaviours. It affects almost all groups of the society. The prevalence and incidence of epilepsy is varying among the countries with heterogeneous figures.

A. Motivation

About 1% of people worldwide (65 million) are suffering from epilepsy, [3] and nearly 80% of cases are in developing countries [4]. Epilepsy becomes more common with the growing age of people [5] [6]. In the developed world, onset of new cases occurs most frequently in infants and the elderly [7] while in the developing world this is in older children and young adults [8], due to differences in the frequency of the underlying causes. It has been observed that about 5–10% of all people will have an unprovoked seizure by the age of 80 [9], and the chance of experiencing a second seizure is between 40 and 50% [10]. In many areas of the world those with epilepsy either have their ability to drive restricted or disallowed [11], but most are able to return to driving after a period of time without seizures. Epilepsy cannot be cured, but seizures are controllable with medication in about 70% of cases [12]. In those whose seizures do not respond to medication, surgery, neuro-stimulation or dietary changes may be considered. Not all cases of epilepsy are lifelong, and a substantial number of people improve to the point that medication is no longer needed.

Automated seizure onset detection will enable the engineering of novel therapeutic and alerting systems

to ease the burden of such seizures. There might be therapeutic system capable of detecting and reacting to the onset of a seizure, a local electrical, thermal or neurochemical stimulus that can halt the progression of a seizure prior to the development of clinical symptoms. Moreover, just-in-time, local therapy could relieve patients of the toxic side effects that accompany systemic administration of multi anti-epileptic drugs. An alerting system equipped with seizure onset detection could warn the patient of seizure prior to the development of the debilitating symptoms, or could notify a family member so that the consequences of a seizure can be limited.

B. Spectral analysis of EEG

As has been mentioned earlier, EEG signals have several spectral components indicating different state of mind. Epilepsy is also indicated with the rise in the energy level of the EEG signal. The multi-resolution analysis of the signal will help in identifying the range of frequencies in which the energy will be higher. The occurrence of epileptic seizure is mostly associated with the higher frequency range usually in the gamma range of EEG. The multi-resolution analysis will help in the effect of the epilepsy in different bands and the one which shows the prominent change before the occurrence of epilepsy can be used as an important feature for further analysis for the onset detection.

C. Onset detection of epileptic seizure

Various state of art designs have been implemented to analyse the EEG signals. EEG signals have been used widely to analyse not just the disorders associated with the brain but also with the various states of the brain like the emotions associated with the nervous systems. Research into seizure detection methods began with the development of seizure event detectors [13], the difference between them being the increased accuracy performance with the later. The detectors developed were meant to detect the seizures of any individual with epilepsy i.e. they were patient non-specific. The variability within EEG severely limited the detection accuracy of such detectors. To improve the performance, investigators developed patient specific event detectors i.e. detectors i.e. detectors that could be tailored to EEG of an individual [14]. Years later, the development of diagnostic and therapeutic applications that require initiation following seizure onset motivated the development of seizure onset detection algorithms.

One of the earliest patient non-specific seizure event detectors was the one developed by Gotman [13] in 1982. The Gotman algorithm searches for the Hallmark sign of seizures i.e. rhythmic activity. The algorithm sequentially searches a number of EEG channels for the presence of rhythmic activity with a dominant frequency between 3-20 Hz and an amplitude at least 3 times greater than that of a background window; whenever the degree of rhythmicity exceeds a threshold on at least two channels and persists for 4 seconds a seizure is declared. The Reveal algorithm developed by Wilson [15] decomposes 2 second EEG epochs from each input channel into time-frequency atoms using the Matching Pursuit algorithm. Hand coded and neural network rules are then employed to determine whether features derived from the atoms of a channel are consistent with a seizure taking place on that channel. Saab developed a patient non-specific seizure onset detector [16] algorithm that uses features derived from a wavelet decomposition of each EEG channel to estimate the probability of a seizure event. Qu developed the first patient specific seizure onset detection algorithm [17] [18] [19] [20]. Shueb had proposed the machine learning based patient specific seizure onset detector [21]. The detector uses a support vector machine to classify a feature vector that automatically encodes the time evolution of spectral and spatial features within the scalp EEG.

A lot of works has been done on the onset detection of the epilepsy however they are confined to the detection of the epilepsy rather than the effort toward the predictive model for the occurrence of the epilepsy. This paper is focussed more on the feature analysis for the earlier detection of the possible occurrence of epilepsy.

II. Algorithm Development

The overall algorithm comprises of basically two major sections. The first one is the extraction of the signal and its pre-processing and the second one is the multi-resolution analysis of the signal.

A. EEG signal extraction and pre-processing

For this research paper, the database of MIT BIH has been used. The different cases presented in the database has been grouped into 23 cases, collected from 22 subjects (5 males, ages 3-22; and 17 females, ages 1.5-19). Here in this paper only one patient out

of them has been chosen as specific case for the study purpose. According to the CHB-MIT database [21] [22] [23] [24], first patient is 11 years old girl. The database contains 41 different EEG sample file in total, each of 1 for almost all the files. So, in total it is a continuous record of 41 hours, with breaks in some of them. Out of these 41 cases, there are six cases of epileptic seizure.

The technical details associated with the signal includes, the usage of sampling frequency of 256Hz, sampling period of 0.00390626 second, duration of 1 hour for most of the data and the 23 leads for the analysis of each case.

B. Discrete wavelet transform of the EEG signal

The Discrete Wavelet Transform analyses the signal at different frequency bands with different resolutions by decomposing the signal into a coarse approximation and detail information. DWT employs two sets of functions, called scaling functions and wavelet functions, which are associated with low pass and high pass filters, respectively. The decomposition of the signal into different frequency bands is simply obtained by successive high pass and low pass filtering of the time domain signal.

The original signal $x[n]$ is first passed through a half band high pass filter $g[n]$ and a low pass filter $h[n]$. After the filtering, half of the samples can be eliminated according to the Nyquist rule, since the signal now has a highest frequency of $\pi/2$ radians instead of π , where 2π is the sampling frequency, f_s in terms of radian. The signal can therefore be subsampled by 2, simply by discarding every other sample. This constitutes one level of decomposition and can mathematically be expressed as follows:

$$Y_{\text{high}} = g[k] \\ = \sum_{n=0} x[n] \cdot g[2k - n] \sum_{n=0} x[n] \cdot g[2k - n] \dots (1)$$

$$Y_{\text{low}} = h[k] \\ = \sum_{n=0} x[n] \cdot h[2k - n] \sum_{n=0} x[n] \cdot h[2k - n] \dots (2)$$

where, $Y_{\text{high}}[k]$ and $Y_{\text{low}}[k]$ are the outputs of the high pass and low pass filters, respectively, after subsampling by 2.

This decomposition halves the time resolution since only half the number of samples now

characterizes the entire signal. However, this operation doubles the frequency resolution, since the frequency band of the signal now spans only half the previous frequency band, effectively reducing the uncertainty in the frequency by half. The above procedure, which is also known as the sub-band coding, can be repeated for further decomposition. At every level, the filtering and subsampling will result in half the number of samples (and hence half the time resolution) and half the frequency band spanned (and hence double the frequency resolution).

With the subsampling operator $\downarrow$ (down-sampling), shown in equation (3), equations (1) and (2) can be written more concisely, shown as equations (4) and (5).

$$(Y\downarrow n)[k] = Y[kn] \dots\dots\dots (3)$$

$$Y_{\text{low}} = (x * g) \downarrow 2 \dots\dots\dots (4)$$

$$Y_{\text{high}} = (x * h) \downarrow 2 \dots\dots\dots (5)$$

C. Calculation of energy of different bands of EEG

DWT decomposes original signal into two different frequency bands in its 1st level decomposition. In this research work, the decomposition has been done up to five levels resulting the six different frequency bands. The so obtained frequency bands are:

TABLE I

Frequency bands and associated range of frequency

Frequency bands	Range of frequency (Hz)
Band 1	0 to 4
Band 2	4 to 8
Band 3	8 to 16
Band 4	16 to 32
Band 5	32 to 64
Band 6	64 to 128

After obtaining the coefficients for these different frequency bands, the energy associated with each of them is calculated using the formulation based on Parseval's theorem as shown in equation (6).

$$ED_i = \sum_{j=1}^N |D_{ij}|^2, \quad i = 1, \dots, l \dots\dots\dots (6)$$

$$EA_l = \sum_{j=1}^N |A_{lj}|^2 \dots\dots\dots (7)$$

where $i = 1, \dots, l$ is the wavelet decomposition level from level 1 to level l . N is the number of the coefficients of detail or approximate at each decomposition level. ED_i is the energy of the detail at decomposition level i and EA_l is the energy of the approximate at decomposition level l . The value of l is taken 5. Since the number of coefficients vary with the level, the values obtained have been scaled down by the number of coefficients.

In DWT, it is very important to choose a suitable wavelet alongside the number of levels of decomposition. Here, the Daubechies 8 has been chosen as a mother wavelet for DWT. The reason behind choosing this wavelet for EEG analysis is its smoothing feature which is suitable for detecting changes of the EEG signals. The scaling function and the wavelet function of this mother wavelet are shown in Fig. 1 and Fig. 2. These wavelets are asymmetric in nature and shows bi-orthogonal nature. This wavelet analysis can represent EEG sub-bands as a weighted sum of shifted and scaled version of an original wavelet without losing any information of energy. Since this transformation can retain the frequency as well time properties of the signal, this is considered superior to the other methods like Fourier transform for this research work.

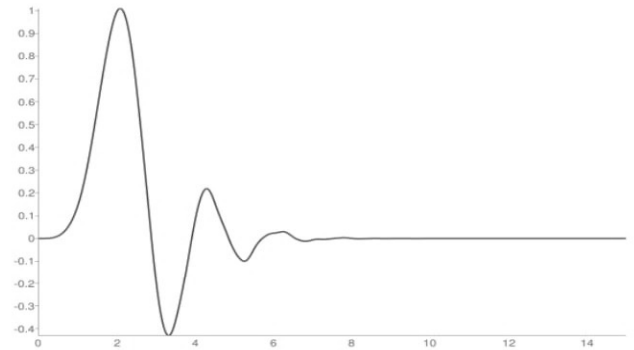


Fig. 1 Scaling function of Daubechies 8 wavelet

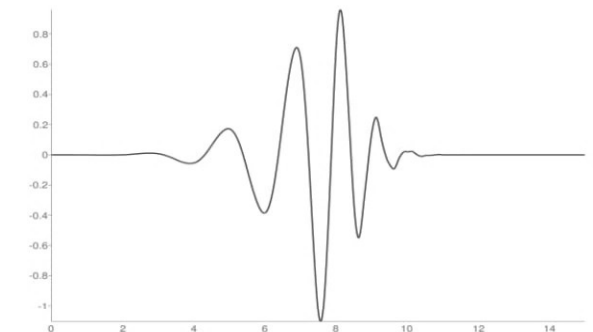


Fig. 2 Wavelet function of Daubechies 8 wavelet

D. Windowing and shifting for energy calculation

For the calculation of the energy of different bands, the calculation is done over a window of 256 samples which corresponds to the duration of 1 second. Next, the window is shifted by 128 samples that corresponds to the duration of 0.5 second. The window so taken is of rectangular nature and this window based calculation helps in obtaining better resolution for time. Next, the shift by 50% i.e. 128 samples with window size of 256 samples will help in eliminating the edge effect of the window. Thus the period of 1 hour i.e. 3600 seconds will give 6 x 7199 values corresponding to the each lead of EEG signal.

III. Result and Discussion

As mentioned in earlier section, the paper is focussed on the analysis of only one patient who is an eleven years old girl. The database contains 41 different EEG sample file of 1 hour of EEG samples each, in almost every file, taken from 23 different leads, resulting the data matrix of size 23 x 921600 for each file. Out of these 41 files, 7 files show the case of epilepsy, namely, chb01_03, chb01_04, chb01_15, chb01_16, chb01_18, chb01_21, chb01_26.

With the window size of 256 samples and shift of 128 sample, 7199 windows were obtained for signal of duration one hour of samples. DWT implementation on each window gave energy for 6 different frequency bands of size 1 x 6 and for 7199 windows, matrix of size 7199 x 6 was obtained as output for every lead. The EEG signal along with its energy spectrum for 6 different bands are shown in figures (3) to (9).

From the observed pattern of the spectral analysis of EEG of different bands, it can be concluded that the first three bands didn't show specific pattern however for the last three bands, a rise in energy is seen earlier to the occurrence of the epileptic seizure. This distinct energy burst could be the one of the features for the early prediction of the occurrence of the epilepsy. Similar observations were seen for the other cases of epilepsy and while testing for the non-epileptic cases, except for few, they weren't present. The details of the results were shown in the Table II.

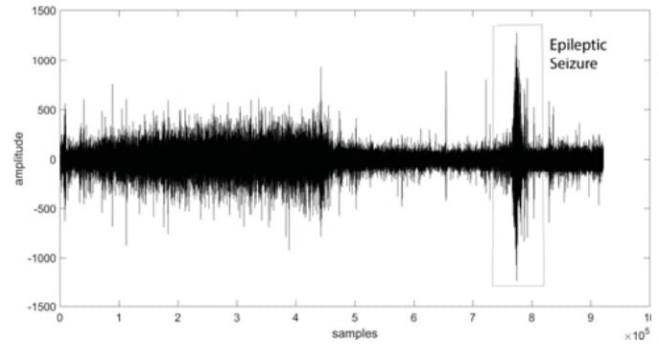


Fig. 3 EEG signal of chb01_03 of lead FPI-F7

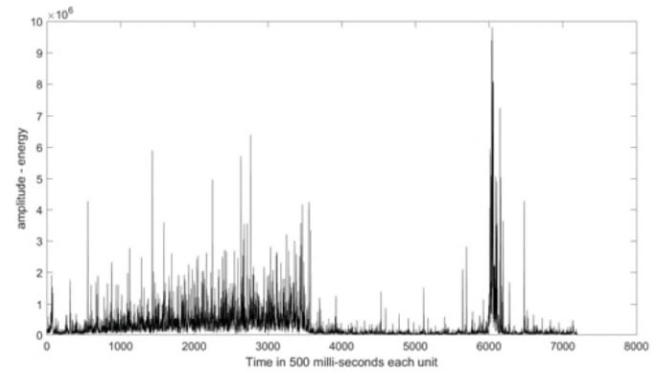


Fig. 4 Energy spectrum of first frequency band (0 to 4Hz)

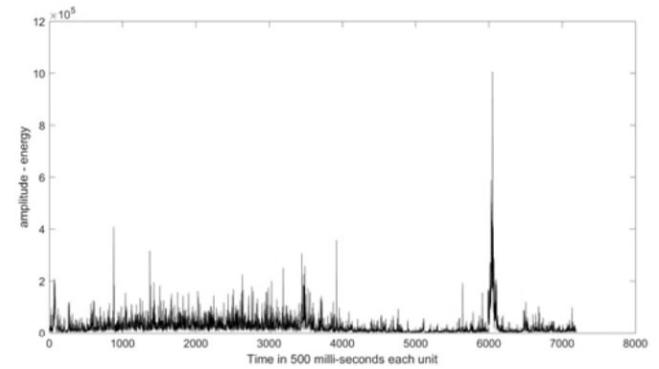


Fig. 5 Energy spectrum of first frequency band (4 to 8Hz)

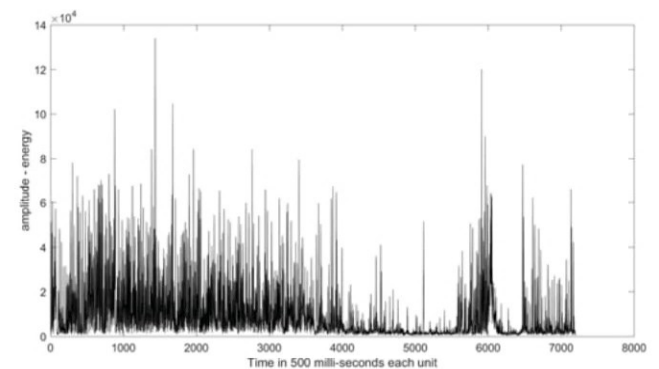


Fig. 6 Energy spectrum of first frequency band (8 to 16Hz)

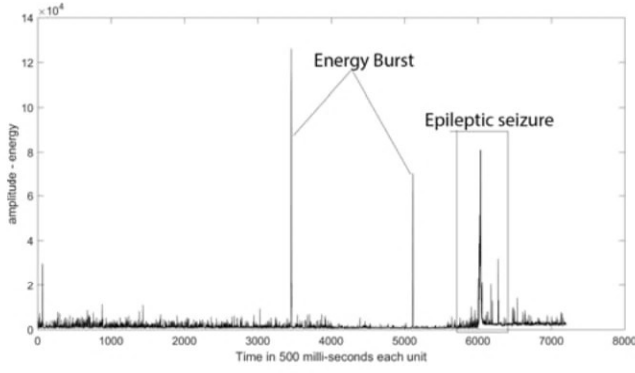


Fig. 7 Energy spectrum of first frequency band (16 to 32Hz)

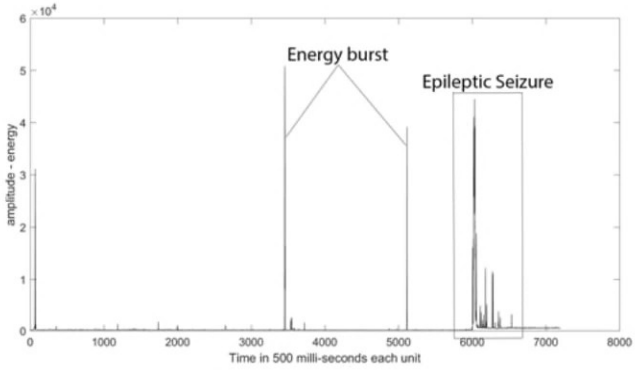


Fig. 8 Energy spectrum of first frequency band (32 to 64Hz)

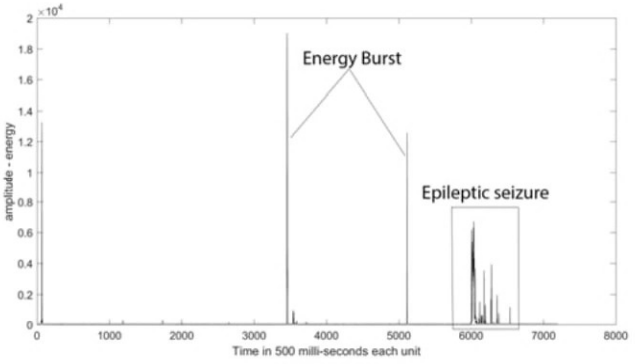


Fig. 9 Energy spectrum of first frequency band (64 to 128Hz)

TABLE II

Comparison of the annotations between actual case and observed one based on pattern

Files	Exact Annotation	Annotation based on pattern observed
Chb01_01	Absent	Absent
Chb01_02	Absent	Absent
Chb01_03	Present	Present
Chb01_04	Present	Present
Chb01_05	Absent	Absent
Chb01_06	Absent	Absent
Chb01_07	Absent	Absent

Files	Exact Annotation	Annotation based on pattern observed
Chb01_08	Absent	Absent
Chb01_09	Absent	Absent
Chb01_10	Absent	Absent
Chb01_11	Absent	Absent
Chb01_12	Absent	Absent
Chb01_13	Absent	Absent
Chb01_14	Absent	Absent
Chb01_15	Present	Present
Chb01_16	Present	Present
Chb01_17	Absent	Absent
Chb01_18	Present	Present
Chb01_19	Absent	Absent
Chb01_20	Absent	Absent
Chb01_21	Absent	Absent
Chb01_22	Absent	Absent
Chb01_23	Absent	Absent
Chb01_24	Absent	Absent
Chb01_25	Absent	Absent
Chb01_26	Present	Present
Chb01_27	Absent	Absent
Chb01_29	Absent	Absent
Chb01_30	Absent	Absent
Chb01_31	Absent	Absent
Chb01_32	Absent	Absent
Chb01_33	Absent	Absent
Chb01_34	Absent	Absent
Chb01_36	Absent	Present
Chb01_38	Absent	Present
Chb01_39	Absent	Present
Chb01_40	Absent	Present
Chb01_41	Absent	Present
Chb01_42	Absent	Absent
Chb01_43	Absent	Present
Chb01_46	Absent	Absent

IV. Evaluation Procedure

For the analysis of the result, positive predictive value (PPV), negative predictive value (NPV) and accuracy were calculated. The positive predictive value (PPV) is defined as the ratio of number of true positive (TP) by the summation of number of true positive and number of false positive (FP). A “true positive” is the event that the test makes a positive prediction, and the subject has a positive result under the gold standard, and a “false positive” is the event that the test makes a positive prediction, and the subject has a negative result under the gold standard. Likewise, the

negative predictive value (NPV) is defined as the ratio of number of true negative (TN) by the summation of number of true negative and number of false negative (FN). A “true negative” is the event that the test makes a negative prediction, and the subject has a negative result under the gold standard, and a “false negative” is the event that the test makes a negative prediction, and the subject has a positive result under the gold standard. The accuracy is calculated as the ratio of summation of true positive and true negative to the summation of true positive, true negative, false positive and false negative [25].

The analysis of the result for 41 cases for different values of TP, TN, FP and FN is shown in Table III.

TABLE III
Observed values for TP, FP, TN and FN

Frequency bands	Range of frequency (Hz)
TP	7 out of 7
FP	0 out of 7
TN	28 out of 34
FN	6 out of 34

Based on the observed values as shown in Table III, the PPV, NPV and accuracy are calculated as 100%, 82.35% and 85.37% respectively.

V. Conclusion

This paper discussed the multi-resolution analysis of the EEG signal under different bands for a specific patient prior to the occurrence of the epilepsy. The observation of 41 different cases of the patient has shown a unique pattern for the epileptic case and non-occurrence for the non-epileptic session with the PPV, NPV and accuracy as discussed in the previous section. Since, the prediction of the occurrence of the epileptic seizure is more crucial to alert the patient or his/her near ones, this finding could be a boon for such and thus can be used a very useful feature for the development of the prediction model for the detection of the onset of the epileptic seizure.

Acknowledgment

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Nepali Text to Speech Synthesis System using FreeTTS

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Abstract

This paper confers the tools and methodology used in developing a Nepali Text to Speech Synthesis System using FreeTTS and is entirely developed in Java and uses FreeTTS synthesizer. Vocalized form of human communication is Speech. Here the Nepali Language is Synthesized based on formant approach and the use of one of the popular generic frameworks FreeTTS that is available in public domain for the development of a TTS system. The Text To Speech Architecture has been developed putting more emphasis on the Natural Language Processing (NLP) component rather than Digital Signal Processing (DSP) component. Nepali language being mostly used language in Nepal and some parts of India and abroad, a text-to-speech (TTS) synthesizer for this language will prove to be a convenient tool and communication technology (ICT) based system to aid to those majorities of people who are illiterate and also to those who are physical impairments like visually handicapped and vocally disabled persons. This ability to convert text to voice may reduce the dependency, frustration, and sense of helplessness of these people. The system can be extended to include more features such as emotions, improved tokenization, interactive options and the use of minimal database.

Keywords— FreeTTS, Nepali Text-to-Speech, ICT, Speech Synthesis.

I. Introduction

Speech is the primary form of communication for human beings. Speech Synthesis is an artificial production of the human speech that allows transformation of the string of phonetic and prosodic symbol into a synthetic speech signal. TTS is a process through which input text is analysed, processed, understood and then the text is rendered as digital audio and then “spoken”.

All the TTS system takes the text in digital format, such as ASCII for English, Unicode for Nepali. The quality of result is a function of the quality of the text, as well as of the quality of the speech generation process itself. The first requirement of TTS system is intelligibility and the second one is naturalness. [1, 2]. Text to speech (TTS) synthesis is the automated transformation of a text into speech that sounds as close as possible, as a native speaker or the language reading the text. Most Text to Speech Systems can be categorized by the method that they use to translate phonemes into audible sound. Some of them are Pre-recorded, Formant, Concatenated, etc.

TABLE I
Comparison between different categories of TTS

Element	Pre-recorded	Concatenated	Formant
Resource requirement	Very large storage, Small memory	Large storage, Very large memory	Low storage, relatively small memory
Vocabulary	Limited	Unlimited	Unlimited
Voice quality	Natural, Most pleasant	Natural	Robotic, sometimes not appreciated by the user
Multiple featured voices	Need high storage in that case	Need high storage in that case	Can produce multiple featured voices without any major changes
Intelligibility	High	Highly Intelligible	High

The TTS system is becoming more interactive and helpful to the users, especially physically and visually impaired and illiterate masses, i.e. not everyone can read text when displayed on the screen or when printed this may be because the person is partially sighted, or because they are not literate and these people can be helped by generating speech rather than printing or displaying it, using TTS system to produce the speech for the given text [3, 4].

So, that the TTS synthesis has a great demand for Nepali language. Speech application are primarily to simplify and automate tasks for human to make it easier assisting them in resolving certain problem domain. TTS synthesis has a wide range of application in

everyday life because no longer people want to sit and read data from the monitor. Since there is painstaking efforts to be taken, this involves strain to theirs eyes. And with the growing popularity of digital material available through internet straight to everyone's handheld devices, the significance of TTS system has grown rapidly.

II. Text to Speech Tools

Text-to-speech synthesis is the automated transformation of a text into speech that sounds, as closer as possible, as a native speaker of the language reading the text. All TTS systems take the text in digital format, such as ASCII for English, Unicode for Nepali [18]. It is possible to build a TTS system which will work in combination with Optical Character Recognition system so that the system can read from printed text; but this does not affect the point, the output of the OCR system will be finally coded in corresponding digital text that is served as input for the TTS system. It is considered that a complete Text-to-speech system for any language must be able to handle text written in its normal form in that language, using its standard script or orthography. Hence a TTS which will accept Romanised input to speak out is not considered as a true TTS system. Normally, a text contains many inputs besides ordinary words. A typical Nepali text may contain numbers in different contexts; amount of money or phone number, percentage, acronyms and so on. A full text-to-speech system should be able to handle all these kinds of inputs with reasonable tolerance [19].

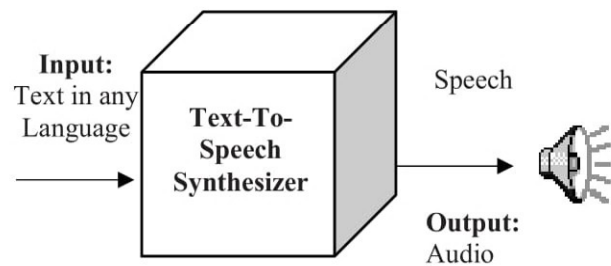


Fig. 1
Schematic Representation of text to speech (TTS) system

The earliest efforts of producing artificial sound were with different mechanical devices which model the human speech production system [6]. The earliest mechanical models had different music instrument like

devices capable of producing only five long vowels each (a, e, i, o, and u). Hence the production of voice was limited to very basic vowels and the process of speech production was not automatic. These were the acoustic resonators modelling the human vocal tract. After a few generations other parts of the machine were improved; like pressure chamber for lungs, vibrating reed to act like vocal cords and leather tube for the vocal tract. With appropriate manipulation of the shape of the leather tube these machines were able to produce vowel sounds and consonants were simulated by separate constricted passages and controlled by the fingers. To simulate more sounds other components were added to the machine, e.g. movable lips, and tongue. Such machines were a good model of the human speech system but were limited to produce phones and limited set of words only, but were unable to produce long sentences.

First full electrical synthesis devices had a buzzer as excitation and resonant circuits to model the acoustic resonances of the vocal tract. These were able to generate single vowel sounds and no consonants. The first true speech synthesizer was introduced by Homer Dudley in 1939, called VODER (Voice Coder). The VODER consisted of wrist bar for selecting a voicing or noise source and foot pedal to control the fundamental frequency. Source signal was passed through ten bandpass filters whose output levels were controlled by fingers. Only skilled operator of VODER could produce a sentence of speech from the device. The demonstration of VODER showed that artificial production of speech was possible and increased more interest towards speech synthesis.

Further study on speech signal and its decomposition invented new technique of speech synthesis called formant synthesis with proper prediction of parameters representing the signal. Formant synthesis does not produce natural sounding speech when operated in fully automated mode to predict the signal parameters. With the advent of digital representation of digital sounds, availability of cheap and powerful computer hardware, and different digital signal processing techniques, speech generation method shifted from fully synthetic to concatenation of natural recorded speech. Speech generated from concatenation method resulted more closely to natural voice than the fully synthesized voice. In addition to this, since memory

cost has been dramatically decreased and the processing speed has been exponentially increased the developers are nowadays interested in different concatenative approaches.

A. Text to Speech Systems for Indian and Nepali Languages

The first Nepali Text-to-Speech synthesizer that was built in 2000 by Sameer K. Maskey while he was doing his under graduation course in Carnegie Mellon University (CMU). The system was based on the Festvox tool built by Alan Black at CMU, US. A presentation of the software was also delivered at RONAST (Royal Nepal Academy of Science and Technology). Unfortunately, this first Nepali Text-to-speech system appears to have been lost.

- 1) **Sambad** : The development of Nepali TTS at MPP began in 2005 with some preliminary reading about Festival and Festvox, and an introduction to speech in Sweden in September 2005. It started in earnest in Jan 2006 with a team of two software engineers (Srishtee Gurung and Ishwor Thapa). By the end of 2006 they had produced Nepali voices for both male and female implemented as a Web based application. This application can be used to read any Nepali text given as an input. In addition to it, in order to produce support for visually impaired and non-literate people the Nepali Voice has been integrated with the Ubuntu version of Linux to produce a Screen Reader, but the same is not available for Windows OS [20].
- 2) **Bharatsanchar NeLRaLEC**: Nepali TTS is being developed using the framework of Festival Speech Synthesis System developed by University of Edinburgh. This is free software which supports multi-lingual speech synthesis and has an open architecture for research in this field.
- 3) **Dhavni** : Indian Language Text-to-Speech System: In India, to help the visually impaired, vocally disabled and day to day increasing applications of speech synthesis has necessitated the development of more and more innovative text-to-speech (TTS) system. Some of the already developed TTS are described below. In this paper four Indian languages text-to-speech systems, namely Dhavni, Shruti, HP Lab system based on Festival framework.

III. Text to Speech Techniques

Naturalness and intelligibility are the two characteristics used to describe the quality of a speech synthesis system [8]. Naturalness of a speech synthesizer refers to how much the output sounds like the speech of a real person and the intelligibility of a speech synthesizer refers to how easily the output can be understood. The ideal speech synthesizer would have both qualities in it and each of the different synthesis technologies try to maximize these characteristics. There are few key technologies used for the generating synthetic speech waveforms: concatenative synthesis, formant synthesis, articulatory synthesis and some are discussed below.

A. Formant Synthesis

Formant synthesis [9] synthesizes speech output using additive synthesis and an acoustic model taking parameters such as fundamental frequency, voicing and noise levels, which are varied over time to create a waveform of artificial speech. This technique is sometimes called rule based synthesis; though, many Concatenative systems also use rule based components. Formant synthesizers are usually smaller programs than Concatenative systems as they do not have a database of speech samples. This is also called the terminal analogy model. Numerous systems built on formant synthesis technology generate artificial, robotic-sounding speech and can be very reliably intelligible, even at very high speeds, avoiding the acoustic glitches that can often plague concatenative systems [3].

B. Concatenative Synthesis

Concatenative synthesis produces the most natural-sounding synthesized speech and is built on the concatenation of segments of the recorded speech, and possible modification of prosody such as modulation and duration [10]. Word level concatenation is not a viable since it requires recording of large level of units. Concatenative synthesis is probably the relaxed method to produce intelligible and natural sounding synthetic speech. Speech is synthesized by connecting pre-recorded natural utterances. However concatenative synthesizers are limited to one speaker and one voice and usually require massive memory than other methods and the significant aspect in concatenative synthesis is to find

correct unit length. Longer units has high naturalness, contains less concatenation points and more control over the variation in phonemes (co-articulation) can be achieved. But the amount of required units and memory goes on increasing and with Shorter Units less memory is needed, but the sample collecting and labelling procedures become more difficult and complex. In contemporary systems units used are usually words, syllables, demi-syllables, phonemes, diphones, and sometimes even triphones.

C. Articulatory Synthesis

Articulatory Synthesis approach is based on computational models of the human vocal tract and the articulation processes occurring there. Few of these models are currently sufficiently advanced and are computationally efficient to be used in commercial speech synthesis systems. This method attempts to model the human vocal organs as perfectly as possible, so it is potentially the most satisfying method to produce high-quality synthetic speech [11] though it possess sufficient computational complexity as compared to other common methods.

IV. Implementation and Discussion

Formant synthesized speech can be very reliably comprehensible, even at very high speeds, avoiding the acoustic glitches that can often plague concatenative systems. Nepali TTS using FreeTTS has been developed based on this approach. The TTS system has text fed as input to generate synthetic speech as output for the corresponding text through audio device to create sound as described here under. After the text is fed to the TTS system the text pre-processing is done i.e. the input text is tokenized and each tokens is first matched and replaced with the English representation of the input Nepali text in the database dictionary. And for the words not found in the dictionary database, undergoes NLP. The text apart from the database is normalized, syllabified according to algorithm that are implemented and after that the syllables of the text is phonetically represented by the English text for each tokens and the tokens are passed to the DSP component to produce the sound of the words that is syllabalized and for other processing in the sound of the input text.

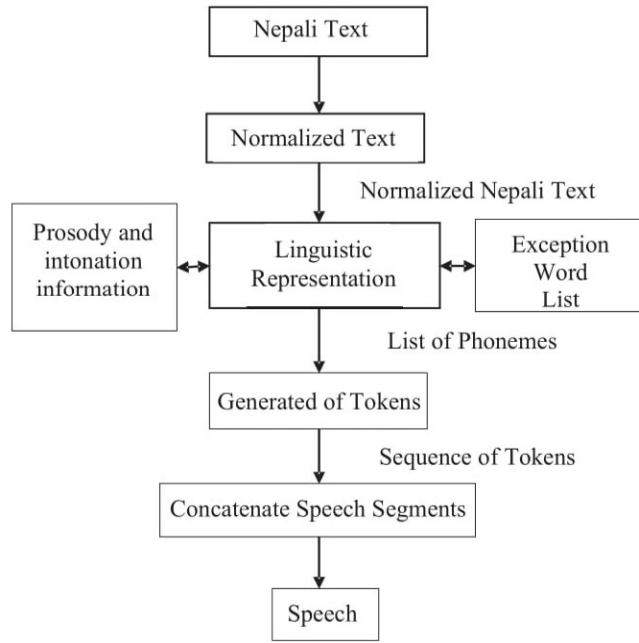


Fig. 2

Basic Flow Diagram of Nepali TTS synthesis System

A. Concatenative Synthesis

The text input will be in Nepali characters or basically in Unicode characters. eg. “मेरो देश नेपाल हो ।” The text is input in Nepali using keyboard that follows the Nepali words and text. The text processing module consists of preprocessing and syllabification.

B. Syllabification

In this approach, the syllabification algorithm breaks a word such that there are minimum numbers of breaks in the word, as minimum number of joins will have fewer artifacts. The algorithm dynamically looks for polysyllable units making up the word, cross checks the database for availability of units, and then breaks the word accordingly. If polysyllable units are not available, then algorithm naturally picks up smaller units. This mean, if database is populated with all available phones of language along with syllable units, algorithm falls back on phones if bigger units are not available. A syllable types are: V, VC, CV, VCC, CVC, CCVC and CVCC etc. where V and C represent vowel and consonant respectively that are used for languages. There are twelve vowel found in Devanagari language the 12 Devanagari vowels. Devanagari script also has about 36 consonants.

Nepali phone set contains 11 vowels, 37 consonants and 21 diphthongs. We have stored these phone set into the speech dictionary to get pronounced by the system which are as below.

TABLE II
List of Nepali Phone Set

Vowel Alphabets (Swar Barna)	अ, आ, इ, ई, उ, ऊ, ए, ऐ, ओ, औ, अं, अः
Consonant Alphabets (Byanjan Barna)	क, ख, ग, घ, ङ, च, छ, ज, झ, ञ, ट, ठ, ड, ढ, ण, त, थ, द, ध, न, प, फ, ब, भ, म, य, र, ल, व, श, ष, स, ह, क्ष, त्र, ज्ञ
Half consonants	क्, ख्, ग्, घ्, ङ्, च्, छ्, ज्, झ्, ञ्, ट्, ठ्, ड्, ढ्, ण्, त्, थ्, द्, ध्, न्, प्, फ्, ब्, भ्, म्, य्, र्, ल्, व्, श्, ष्, स्, ह्, क्ष्, त्र्, ज्ञ्

The system takes the Devanagari input and tokenizes each word in the input. Then, the tokens are checked and replaced in the database. And if not found in the dictionary, the text is goes NLP process where it is normalized i.e. it converts the non-standard word into standard words as the sentence may contain the abbreviation, numbers, and it needs to be converted into the words done by the normalization process. It then undergoes for syllabification (i.e. no of vowel with half consonant used in the formation of word like क् आं स् अ . काम. Here c and cf is a vowel with half consonant s\ and d\ to form a word sfd) and phonetically equivalent English representation of Nepali phonemes is done (i.e. काम = kaama) for each tokens. Then those sequence of tokens are put into the FreeTTS[19] speech engine from where the speech output is generated

Algorithm 1: For Tokenization Process,

Input: Nepali Text Input (S_i)

Output: Tokens (T_i)

Begin,

Step 1: Parse all text (S_i) with the whitespace in the input text; where $i = 1, 2, 3, \dots, n$.

Step 2: For each input text (S_i)

Extract words $W_i = S_i$; where $i = 1, 2, 3, \dots, n$.

Apply extract process for all text words $i = 1, 2, 3, \dots, n$.

Step 3: For each extracted words in Step 2,

Store $S_i[] = W_i$; where $i = 1, 2, 3, \dots, n$.

Apply store for all words.

Step 4: $T_i = S_i$;
Return (T_i).
Step 5: Pass value T_i for further processing.
End.

Algorithm 2. For Word Map from Dictionary,

Input: Tokens $W = T_i$, where $i = 1, 2, 3, \dots, n$.
Output: English Words (W_e).
Begin,
Step 1: For every word $W \leftarrow$ Word from Tokenization;
Length of the word (strlen);
Step 2: For $W \in D$
Select_Word $\leftarrow$ Dictionary D ;
Step 3: If
 $W = \text{Select_Word}$
Return Word [1];
Else
Return W ;
End.

Algorithm 3. For Natural Language Processing,

Input: Token W from Word Map check
Output: English Word (W_e)
Begin,
Step 1: For Every Word W
Check whether if the Word (W) is Numeric or Abbreviation,
Get the values of Numeric Characters or the Full Form for W .
Return Replaced_Word (W).
Step 2: For Every Replaced_Word (W)
Construct the Word, according to the Phone Set and Grammar.
Represent the word with syllables;
Return Syllabified_Word (W).

Step 3: For Every Syllabified_Word (W)
Map the Syllables with its Phonetically Equivalent Characters
Return Phonetic_Word(W).
End.

V. Analysis and Evaluation

Free TTS is a speech synthesis system written entirely in Java and is based upon Flite (a small run-time speech synthesis engine developed at Carnegie Mellon University). Flite is derived from Festival Speech Synthesis System from University of Edinburgh and FestVox project from Carnegie Mellon University. Free TTS now has the ability to import voice data from FestVox (US English only). With this, user can record their own voice using the FestVox tools, and then turn the resulting data into a Free TTS voice. For the project Free TTS is used as the DSP component for the Development of the TTS system.

For Evaluation Listeners are asked to rate the speech quality of the system, usually synthesizing the same set of sentences. Typically subjects are asked to rate the naturalness of the synthesis on a scale of 1-3, where 1 is poor, 2 is average and 3 is natural or gives correct pronunciation. All results are summed, and a mean score between 1 and 3 is derived, which is meant to represent the oral naturalness rating for the system.

The evaluation is done on the basis of:

- Intelligibility (how much of the spoken word can be understood)
- Naturalness or Pronunciation (how close to human speech does the output of the TTS system sound)

Test has been done to know whether the system has natural sounding or not as well as does it, sound closer to the real sound as human speak or not.

A. Evaluation of Individual Character

The Nepali language has 36 consonant and 11 vowels and 10 number characters for which evaluation was done to tabulate as below.

TABLE III

Evaluation of numbers, vowel and consonant used in test

S.N	Categories	Perfect Sounding	Average Sounding	Poor sounding
1.	Number	०, १, २, ५, ६, ७, ८	३	४, ९
2.	Vowel	आ इ ई उ ऊ ए ऐ ओ औ	अ	अं
3.	Consonant	क ख ग च छ भ ट ड त थ द ध न प फ भ म य र ल व स ष श ह ञ	घ ढ ठ ण ज ब क्ष	ड ञ ज्ञ

Here, the test has been done to determine the naturalness i.e. accurate pronunciation of the number in the TTS system. The work has been done by dividing the task into three categories i.e. perfect, average, poor sounding characters. According to the evaluation the numbers like ०, १, २, ५, ६, ७, ८ are pronounced perfectly, the average sounding number is ३ and poor sounding numbers includes ४, ९. After calculation the accuracy was obtained and the accuracy for the perfect sounding is 70%, average sounding is 10%, and poor sounding is 20%. In this test rating is done for each categories i.e. for perfect sounding rate is given as 3, for average rate is given 2 and for poor rate is given 1. From which the weight is calculated of each categories to obtain the overall performance of number in the TTS system and its overall performance accuracy is 83.33% for numeric character set.

The perfectly pronounced vowel are आ इ ई उ ऊ ए ऐ ओ औ and its accuracy is 81.81%, the average sounding vowel is अ and its accuracy is 9.09%, the poor sounding vowel is अं and its accuracy is 9.09. After calculating the weight according to the rating method the overall performance accuracy is obtained as 90.90%.

Further, individual character or consonant that is perfectly pronounced are क ख ग च छ भ ट ड त थ द ध न प फ भ म य र ल व स ष श ह ञ and its accuracy is 72.97%, average sounding consonants are घ ढ ठ ण ज ब क्ष and its accuracy is 18.91%, poor sounding consonants are ड ञ ज्ञ and its accuracy is 8.10%. Then weight is calculated according to the rating and then overall performance accuracy is obtained which is 88.28%.

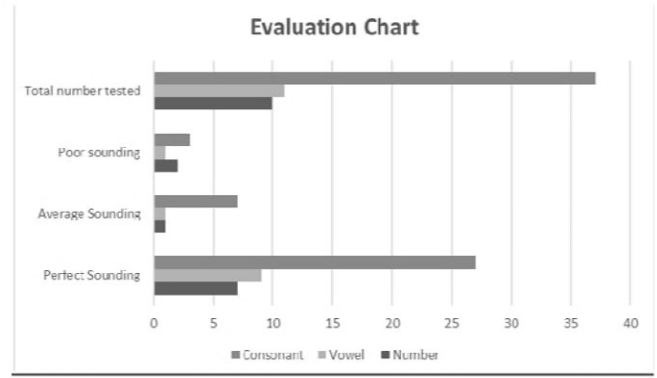


Fig: Evaluation Chart for Vowel, Consonants and Numeric

B. Evaluation of Individual Word

In the evaluation of the individual words the total words tested in the test were 2000 in which total natural sounded words are 1318, average sounded words are 257, and poor sounded words are 425. After analyzing the weight the overall performance were noted which is 81.56%.

TABLE IV

Evaluation Table for Individual keywords

Individual words	Perfect Sounding (3)	Average Sounding (2)	Poor Sounding (1)
Words used in test	1318	257	425
Accuracy of total words in percentile	65.9	12.85	21.25

Overall Performance

$$= (\text{Sum of weighted words in all categories} / \text{Total Weighted words}) * 100$$

$$= (3954 + 514 + 425) / 6000 * 100$$

$$= 81.5$$

Overall performance of the Nepali TTS system was found out to be 81.5% of the developed Nepali Text to Speech System

VI. Conclusions

This paper discussed the various steps involved in developing the Nepali text to speech synthesis system based on Formant Synthesis approach using FreeTTS. In the current system, linguistic feature such as intonation and prosody has not been implemented.

Further enhancement of the system could incorporating these features. However the system produces flat speech for any inputted Nepali text, though the synthesized speech doesn't sounds as natural as that spoken by a human. The system can be extended to include more features such as emotions, improved tokenization and use of minimal database.

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Comparative Analysis of Memristor based Synaptic Circuits for Neuromorphic Architectures



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Abstract

Memristor is one of the fundamental electrical elements, which has recently been successfully built. Memristor is being used extensively as synapses in neuromorphic applications. A common method for developing memristor based synaptic circuits is to store synaptic weight values within memristors as resistance values. It requires use of the continuous resistance (memristance) range available in the memristors to store the weights. In this paper, we study how different compact synaptic circuits implemented using TiO_2 memristors to perform zero, negative, and positive synaptic weightings. Results of different memristor based circuits, based on pulsed input signals, are compared, analyzed and presented using TiO_2 memristors via simulations.

Key words – Memristor, Memristance, synapses, neuromorphic.

I. Introduction

The existence of the “memristor” as the fourth basic circuit element was predicted by Leon Chua in 1971 [1]. The prediction was based on symmetry and a missing relationship between an independent pair of the four fundamental circuit variables: current (i), voltage (v), charge (q), and flux linkage (ϕ). The three basic circuit elements, resistor, inductor and capacitor are defined by a relationship between v and i , ϕ and i , and q and v , respectively, but the relationship between q and ϕ was missing. For the sake of symmetry and completeness, the memristor was postulated in [1] as the fourth basic two-terminal circuit element characterized by a relationship between q and ϕ .

Memristor is defined in [2] by a state-dependent Ohm’s law between the memristor-voltage v and memristor-current i as,

$$v = M(x_1, x_2, \dots, x_n) i \quad (1)$$

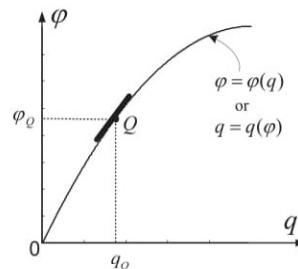


Fig. 1 Nonlinear function between flux and charge. The memristance $M(q)$ can be obtained by calculating the slope at $q = q_Q$

where M is called the memristance and x_i' are the state variables. The state variables $x_1, x_2, \dots, x_n$ are defined by “ n ” differential equations called the associated state equations, as follow:

$$dx_k/dt = f_k(x_1, x_2, \dots, x_n; i), \quad k = 1, 2, \dots, n \quad (2)$$

In the special case where the device possesses only a single state variable x and $f(x, i) = i$, then $x = q$ is the charge entering the memristor and the device is called an “ideal memristor”. The memristor is defined by,

$$v = \frac{d\phi(q)}{dq} \frac{dq}{dt} = M(q)i \quad (3)$$

where ϕ and q denote the flux and charge, respectively. Thus, the memristance $M(q)$ can be interpreted as the slope at the operating point $q = q_0$ on the memristor $\phi-q$ curve as in Fig. 1. If the $\phi-q$ curve is nonlinear, the resistance will vary with the operating point. Since the resistance in this type of device is variable depending upon the operating point $q = q_0$, and since $q = q_0$ remains fixed when $v(t) = 0$ and $i(t) = 0$, the device can be used as a non-volatile memory. A dynamical system described in [2] by equations

$$v = M(x)i \quad (4)$$

$$M(x) = R_{ON}x + R_{OFF}(1-x) \quad (5)$$

$$dx/dt = Ki \quad (6)$$

is an example of a memristor, where i is the input current, v is the output voltage, R_{ON} , R_{OFF} and K are the system parameters, x is the state variable, and $M(x)$ is its memristance.

The researchers from *hp* group has announced the successful development of a very compact memory element made of Titanium Dioxide [2], which exhibited the pinched hysteresis loop fingerprint of memristors.

In neural networks, incoming signal are multiplied with synaptic weights and outputs are obtained by passing through activation functions after the summation of the weighted input signals. Hardware implementation of the neural networks might be an essential step to solve the real time processing problem of neural networks. The success of each neural network hardware design depends largely on the trade-offs between accuracy, chip area and processing speed.

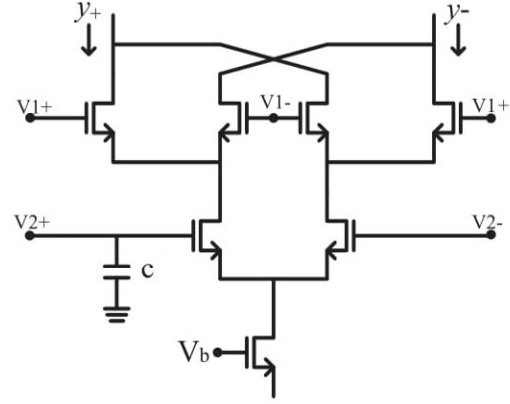


Fig. 2 Conventional CMOS synaptic circuit [3].

Unlike their digital counterparts, analog implementations are usually more efficient in terms of chip area and processing speed but they have limited accuracy which arises due to spatial non-uniformity of the analog components and their non-ideal responses. In addition, another major bottleneck in ANN hardware is the implementation of nonvolatile weight storage [4]. Resistors are static and cannot be changed once fabricated, thus they can be used only for non-learning hardware. Capacitors have short synaptic weights retention time due to charge leakage and require dynamic weight updating at frequent intervals. Floating gate transistors have been used successfully as synapses in conjunction with analog multipliers, but they suffer from high non-linearity in synaptic weightings. Memristor is a two terminal electrical element, which exhibits features of biological synapse under the excitation of input voltage or current pulses: its resistance can be altered in a manner, similar to bio-neurons, to emulate change in synaptic weight. Likewise the two memristors with anti serial connection can be used to generate both positive and negative weights. Composite behaviour of memristor circuits has been published in [5] which led to explore the varieties of applications of memristors. Recently few artificial synapses consisting of multiple identical memristors in a bridge-like fashion capable of performing signed synaptic weights were proposed in [6-7]. Memristor bridge circuit which is composed of four identical memristors is able to perform zero, negative and positive synaptic weightings is developed. Together with three additional transistors, the memristor bridge weighting circuit is able to perform synaptic operation for neural cells. By programming different values on each memristor of the memristor bridge circuit,

arbitrary weighting values can be set on the memristor bridge synapses.

The unique features of memristor-based neural architectures are their pulse-based operation, compact and adjustable weighting, non-volatile memory and linearly synaptic operation. In this paper, several memristor based synaptic circuits are studied and analyzed.

II. Conventional CMOS synapse

Normally, CMOS analog multipliers are employed to compute the multiplication between input signals and weights in neural networks [2]. As the neural networks have massive interconnectivity and are parallel in nature, it is required that the multipliers should be smaller, consume low power and non-volatile. The multiplication between weights and input signals should be linear. However, it is very difficult to get the

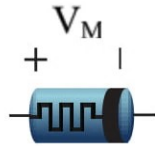


Fig. 3 A single memristor

Above features in CMOS analog multipliers. To implement such an immense amount of processing into a chip, extremely high density of analog multiplier is needed. Multiplication in a typical analog Gilbert circuit is usually implemented with at least seven transistors, as shown in Fig. 2, operating in a nonlinear and hence power-hungry regime. Therefore, significant nonlinearity is unavoidable in multiplication processing with conventional CMOS transistor circuits.

III. Memristor Synapses

A. Single Memristor Synapse

The memristance/memductance of a two-terminal memristor as shown in Fig. 3 can be varied by varying the current passing through it such that a memristor can be used as a synapse. The memductance of the memristor is analogous to the strength of the synapse. As memristor is a non-volatile device it retains its conductance when there is no external input, and the conductance can be changed by applying appropriate external signal to emulate change in synaptic weight.

B. Two Memristor Synapse

Though a single memristor can be efficiently implemented as synapse in neural learning circuits, a single memristor lacks the ability to emulate negative weights which are commonly encountered when implementing artificial neural learning rules like back-propagation. But negative weights can be realized by utilizing other measurable quantities like current or voltage across appropriately connected memristor(s).

It consists of two identical anti-serial memristors with the polarities indicated as in Fig. 4. When an input pulse V_{in} is applied to the circuit, the memristance of each memristor increases or decreases depending on the polarity. For instance, if positive V_{in} is applied, the memristance of M1 decreases whereas the memristance of the reversely biased memristor M2 increases. Similarly, if negative V_{in} is applied the memristance of M1 increases whereas that of M2 decreases. The difference in the voltage drop across the memristor M1 and M2 then can be utilized to achieve positive and negative synaptic weights.

If V_{in} is applied to the circuit shown in Fig. 4, then using KVL, the input voltage is the sum of the voltage drop across memristor M1 and the voltage drop across memristor M2. The individual voltage drops across M1 and M2 are given as,

$$v_{M1} = \left(\frac{M1}{M1 + M2} \right) v_{in} \quad (7)$$

$$v_{M2} = \left(\frac{M2}{M1 + M2} \right) v_{in} \quad (8)$$

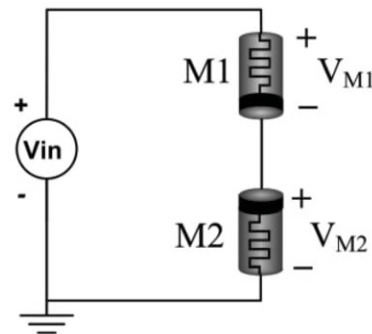


Fig. 4 Two anti-serially connected memristors

Then, the voltage of interest is the voltage difference between v_{M2} and v_{M1} given as

$$\begin{aligned} v_{out} &= v_{M2} - v_{M2} \\ &= \left(\frac{M2 - M1}{M1 + M2} \right) v_{in} \end{aligned} \quad (9)$$

From Eq. (9) we see that the arrangement in Fig. 4 performs synaptic weighting of the input signal V_{in} , where the output is a weighted function of the input and the weighting function is given as

$$\alpha = \left(\frac{M2 - M1}{M1 + M2} \right) \quad (10)$$

The conditions for the anti-serial memristor arrangement to function as weight in different regimes is listed as follow.

If $M2 > M1$, positive synaptic weight

If $M2 < M1$, Negative synaptic weight

If $M2 = M1$, Zero synaptic weight

C. Five-Memristors Bridge-Based Synapses

In the memristor weighting circuit, both positive and negative multiplications are performed via a charge-dependent Ohm's law ($v = M(q) \times i$). The circuit is composed of five memristors with bridge-like connections together with one differential amplifier. It operates like an artificial synapse with pulse-based processing and non-volatile adjustable weightings.

The sign-setting, weight-setting (positive or negative) and the processing signals are applied through a common input terminal. It is assumed that the voltage which is generated internally by current signal makes the same amount of memristance change as that by the same magnitude of the externally applied voltage. The memristor M_w at the center plays the weighting role of the synapse and the other memristors, M_{s1} , M_{s2} , M_{s3} and M_{s4} function as switches for selecting the weighting sign.

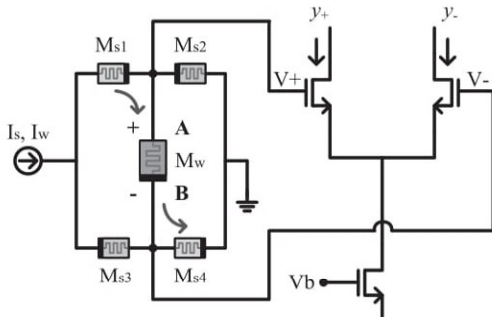


Fig. 5 Memristor-based synaptic circuit.

The memristors alter the sign of the input voltage of the differential amplifier by switching the on-off states of the memristors in the manner of a bridge circuit. Though five memristors are employed to emulate a synapse in circuit, the total area of the five memristors is less than that of a single transistor.

Sign Setting

Prior to weight setting or multiplication processing, the sign of the synaptic weight is set first. This is implemented by applying a strong current pulse (high amplitude or wide current pulse) to change the memristances toward one of the two extreme values (In the TiO_2 memristor it is assumed that a turn-on resistance 116Ω , and turn-off resistance $15.98 \text{ K}\Omega$).

When a positive wide pulse is applied at the input terminal of the memristor circuit, as shown in Fig. 5, the charge of both memristors M_{s1} and M_{s4} increases while that of M_{s2} and M_{s3} decreases. Note that the polarities of memristors M_{s1} and M_{s4} are opposite from those of M_{s2} and M_{s3} . Accordingly, the magnitude of the resistances of memristors M_{s1} and M_{s4} decreases, while that of M_{s2} and M_{s3} increases.

If the magnitude or the duration of the pulse is big enough, the memristance of memristors M_{s1} and M_{s4} will reach its minimum value, while that of M_{s2} and M_{s3} will attain its maximum value, thereby resulting in an on (low memristance) state for M_{s1} and M_{s4} , and an off (high memristance) state for M_{s2} and M_{s3} . Afterward, any current signal appearing at the input terminal passes mostly through M_{s1} , M_w and M_{s4} . Consequently, a larger voltage is produced at terminal $V+$ than that at terminal $V-$ with a positive current i . In this case, memristor M_w functions as a positive weight thereafter. On the other hand, when a negative wide pulse is applied as shown in Fig. 5, the voltage appearing at terminals $V+$ and $V-$ will be opposite to that of the previous case. In this case, the value M_w functions as a negative weight thereafter.

Weight Setting

After the sign setting operation, the memristance is set for the synaptic weight. A pulse with a smaller width in the range $[0, 0.7 \text{ ms}]$ is applied in this case. The equivalent range of the memristance M_w is $[116 \Omega, 1 \text{ K}\Omega]$ in the TiO_2 memristor model.

D. Four-Memristors Bridge-Based Synapses

The bridge circuit consists of four identical TiO_2 memristors and is able to perform positive, negative and zero synaptic weighting. When a positive or a negative pulse V_{in} is applied at the input, the memristance of each memristor M_1 , M_2 , M_3 and M_4 is changed depending upon its polarity. For instance, when a positive V_{in} is applied as input, the memristance of M_1 and M_4 (whose polarities are forward biased) will decrease whereas the memristance of M_2 and M_3 (whose polarities are reverse biased) will increase. It follows that the voltage V_A at node A (with respect to ground) becomes larger than the voltage V_B at node B for a positive input signal. In this case, the circuit produces a positive output voltage V_{out} representing

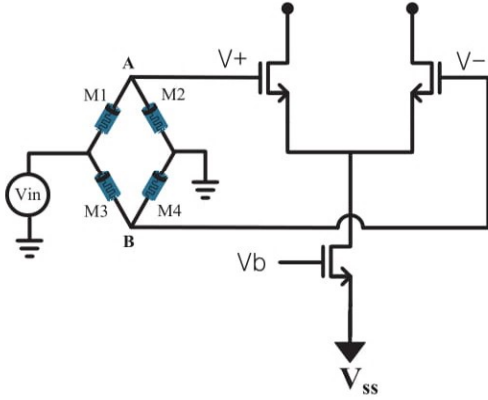


Fig. 6 Memristor bridge synaptic circuit.

a positive synaptic weight. On the other hand when a negative V_{in} is applied, the voltage at node B becomes larger than the voltage at node A and the circuit produces a negative output voltage V_{out} representing a negative synaptic weight. The voltage at different nodes in the circuit of Fig. 6 is given as

$$v_{M1} = \left(\frac{M_1}{M_1 + M_2} \right) v_{in} \quad (11)$$

$$v_{M2} = \left(\frac{M_2}{M_1 + M_2} \right) v_{in} = v_A \quad (12)$$

$$v_{M3} = \left(\frac{M_3}{M_3 + M_4} \right) v_{in} \quad (13)$$

$$v_{M4} = \left(\frac{M_4}{M_3 + M_4} \right) v_{in} = v_B \quad (14)$$

The required output is the voltage difference between terminal A and terminal B given as

$$v_{out} = v_A - v_B = \left(\frac{M_2}{M_1 + M_2} - \frac{M_4}{M_3 + M_4} \right) v_{in} \quad (15)$$

From Eq. (15) we see that the output voltage is equal to the input voltage weighted by a factor ψ , where

$$\psi = \left(\frac{M_2}{M_1 + M_2} - \frac{M_4}{M_3 + M_4} \right) \quad (16)$$

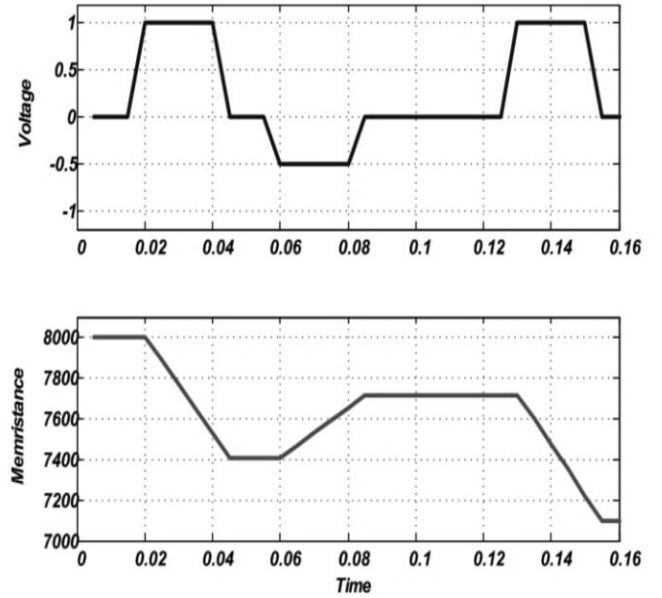


Fig. 7 Variation of Memristance of the TiO_2 memristor by applying voltage signal.

The conditions for the bridge to function as weights in different regimes are listed as follow:

$$\frac{M_2}{M_1} > \frac{M_4}{M_3} \text{ Positive synaptic weight}$$

$$\frac{M_2}{M_1} < \frac{M_4}{M_3} \text{ Negative synaptic weight}$$

$$\frac{M_2}{M_1} = \frac{M_4}{M_3} \text{ Zero synaptic weight}$$

Each neuron must add a set of weighted input signals from diverse sources. This is implemented in the memristor bridge neuron via summing input signals with current mode circuits. The differential amplifier with three transistors in Fig. 6 is the voltage-to-current converter which functions as a current source.

IV. Simulation Results

The memristance of the TiO_2 memristor can be changed by applying appropriate current (or voltage) signal and the memductance remains unchanged whenever there is no external input as shown in Fig. 7.

Fig. 8 (a) shows the variation in memristance of the two TiO_2 memristors M1 and M2 and Fig. 8 (b) shows the change in synaptic weight when a programming input voltage V_{in} is applied to the circuit in Fig. 4. As can be seen from Fig. 8 (b), positive, negative and zero synaptic weighting can be performed with two anti-serial memristors as shown in Fig. 4. One possible implementation of memristor-based synapse that can emulate both positive and negative synaptic weights is shown in Fig. 8.

The five memristor synaptic circuit allows positive and negative weighting. The initial memristances $M_{s1}=M_{s4}$ and $M_{s2}=M_{s3}$ are assumed 15.98 KOhms and 116 Ohms, respectively. For the input current I , the voltage across M_w can be computed as $-0.98 M_w \times I$. Therefore, the initial sign of the weighting with the above memristances is negative. Fig. 9 shows the transition of the memristance at each memristor while a positive current pulse with +10mA amplitude is applied. At the end of the pulse, the memristances are turned into $M_{s1}=M_{s4}=116 \text{ Ohm}$ and $M_{s2}=M_{s3}=15.98 \text{ KOhm}$.

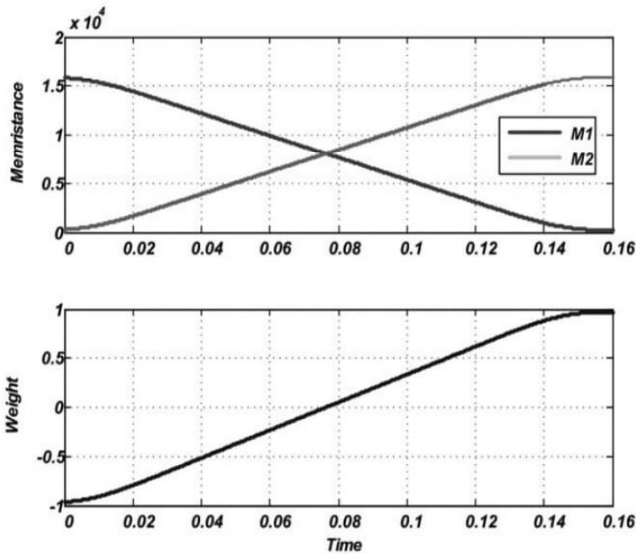


Fig. 8 Variation in memristance of the two TiO_2 memristors and (b) the weight programmed when a voltage 1V is applied to the circuit.

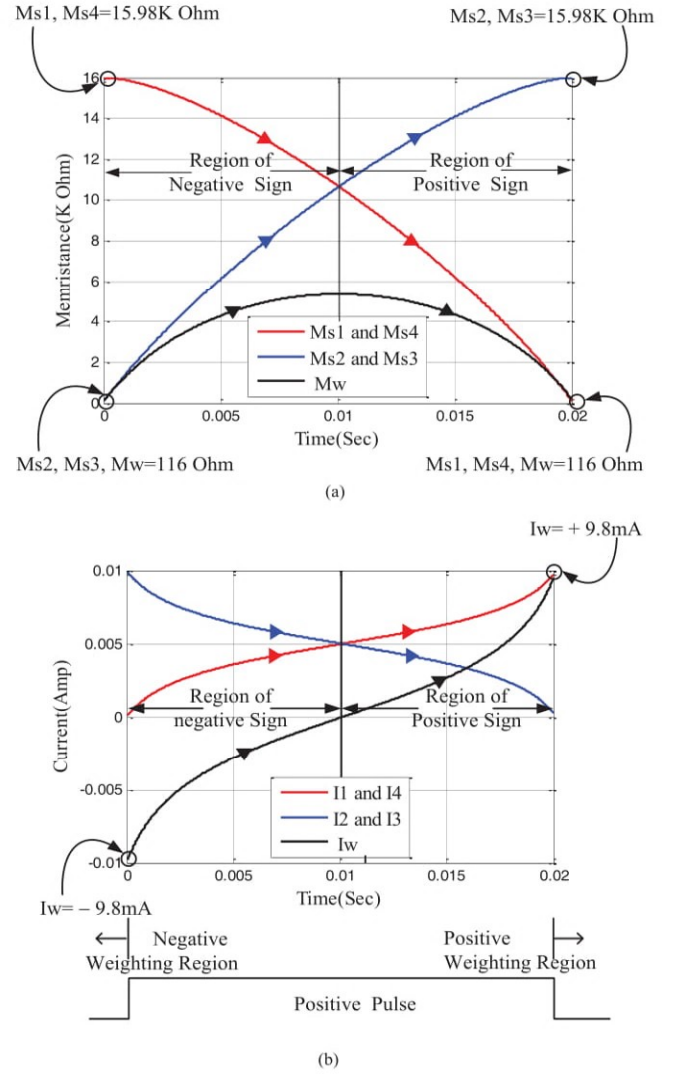


Fig. 9 (a) Memristance transition from $\{M_{s1}=M_{s4}= 15.98 \text{ K}\Omega, M_{s2}=M_{s3}= 116 \Omega\}$ to $\{M_{s1}=M_{s4}=116 \Omega, M_{s2}=M_{s3}= 15.98 \text{ K}\Omega\}$. (b) Weight programmed.

Note that both the negative and positive signs can be obtained in the whole regions of the left and right side of Fig. 9, respectively. However, a shorter time is taken to program the same amount of memristance value in the two extreme state regions than in the middle regions. Similar to the positive sign transition as above, the negative sign can be implemented when a negative pulse is applied at a positive weighting state.

Fig. 10 shows the variation of memristance of the four memristors M1, M2, M3 and M4 and the corresponding synaptic weight realized when an input voltage V_{in} is applied to the circuit in Fig. 6. The bridge circuit can be used as synaptic weight in ANNs to realize positive, negative and zero weightings. Fig. 10

(a) shows the changes in the memristances $M_1(t)$, $M_2(t)$, $M_3(t)$ and $M_4(t)$ as a function of time, obtained via computer simulations of the memristor bridge circuit in Fig. 6 with initial memristances, $M_1(0) = M_4(0) = 14.41 \text{ k}\Omega$, $M_2(0) = M_3(0) = 1.69 \text{ k}\Omega$. As shown in the figures, these numerically computed memristances in Fig. 10 (a) and the corresponding weight in Fig. 10 (b) are all very linear.

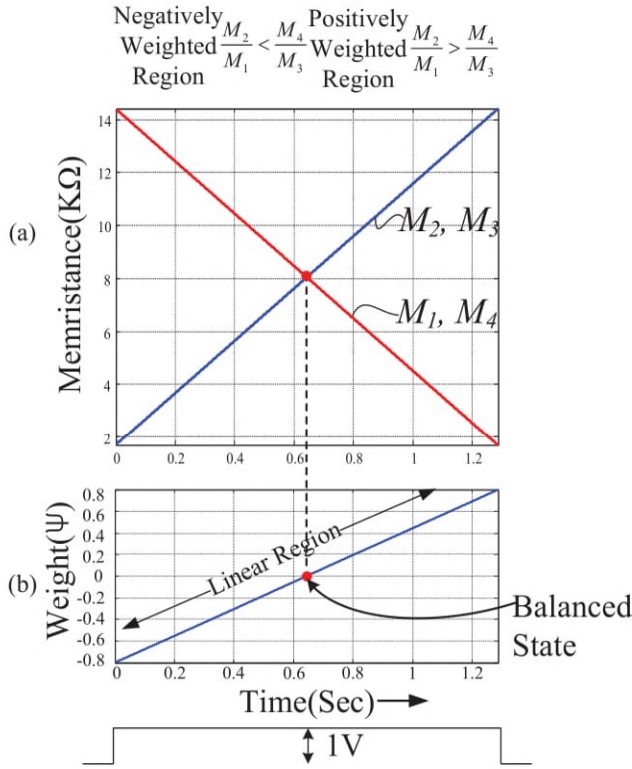


Fig. 10 (a) Time variations of $M_1(t)$, $M_2(t)$, $M_3(t)$, $M_4(t)$, and $\psi(t)$ with memristor bridge circuit when a wide pulse is applied. The linear memristor model is assumed. (b) weight $\psi(t)$.

V. Comparison of the four Synapse Structures

Different pulse-based programmable memristor circuits for neural network applications are compared. The single memristor synapse is the simplest of all the four structures of memristor synapses discussed above. Since the conductance of memristor is directly used as analogous to synaptic weight, the output voltage across the memristor (or current through it) can be used directly to feed to the succeeding modules in the neural learning circuit. The two-terminal structure of the memristor can easily be integrated with the rest of

the neural learning circuit. Though simple in structure and easy to implement, the single memristor synapse has severe limitations in application due to the inability of implementing zero and negative synaptic weighting directly using conductance.

Whereas the two-memristor synapse and the memristor bridge synapse utilize the difference of voltage at different nodes in their structure to realize synaptic weights. Hence auxiliary circuits are required to make the output usable for succeeding layers when used in neural learning circuit. The two-memristor synapse however requires relatively more number of CMOS components in the auxiliary circuit than the four memristor bridge synapse. CMOS components occupy almost three orders of magnitude more chip area than a memristor. Therefore, more CMOS components means more chip area utilization.

The two memristor synapse and the five and four memristor bridge synapse however can implement positive, negative and zero weighting and have no restriction in applications and are particularly useful for applications where the weights are not known theoretically.

The single memristor synapse is particularly not suitable for implementing ANN rules like Back Propagation where the synaptic weights are not known a-priori and the weights can evolve either as positive or negative weights during learning.

The architecture of the five memristor bridge circuit is able to perform signed synaptic operations. However, it is very difficult to program small weighting near to zero. Moreover, a sign setting has to be performed before the weight setting of the input signal. The memristance of the switching memristors are also affected during the weight setting.

Also, a bridge synaptic circuit with four memristors, which is even simpler and efficient than five memristor based synaptic circuit. It is composed of four identical memristors that is able to perform zero, negative and positive synaptic weightings. Together with three additional transistors, the memristor circuit bridge weighting circuit is able to perform synaptic operation like an artificial neural cell. The memristor bridge based circuit has linear output characteristic compared to the conventional CMOS based Gilbert multiplier.

VI. Conclusion

The non-volatile property and nano-dimension of memristor makes it a suitable component to be used as synapse for realization of simple and dense neural learning circuits. Use of conductance of a single memristor, analogous to the synaptic strength, is the simplest way to realize synapse in neural circuits. However, it can be applied only as positive weights. Combination of different memristors in a circuit can be utilized as synapse capable of performing positive, negative and zero weighting, like the two-memristor synapse and the memristor bridge-based synapse. But these structures require additional circuitry to extract the useful output which when realized with CMOS circuitry occupy greater chip area. Five memristor based synapses showed positive, negative and zero weighting, however, it shows the nonlinearity. Comparatively, the memristor bridge-based synapse requires less number of CMOS components than the two-memristor synapse and this makes the memristor bridge-synapse a better choice for implementing synapse in neural learning circuits.

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Design of Low Noise Amplifier for 1.5 GHz



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Abstract

Low Noise Amplifier (LNA) is a front-end device of a radio frequency (RF) receiver used to increase the amplitude of an RF signal without much additional noise, thereby increasing the noise figure of the system. This paper presents design, simulation, and prototype of an LNA operating at 1.5 GHz for the bandwidth of 100 MHz. The circuit was simulated using Advanced Design System (ADS). The components used are Surface Mount Devices (SMDs); with transistor "Infineon BFP420" as a major component. Other components are resistors, capacitors, and inductors; inductors being superseded by microstrip lines. The circuit was fabricated on FR4 board. The measurements of several parameters of LNA were made using Vector Network Analyzer (VNA), Noise Figure Meter, and Spectrum Analyzer. The LNA has minimum gain of 15.4 dB and maximum noise figure of 1.33 dB. It is unconditionally stable from 50 MHz to 10 GHz. DC supply is 5V and the current consumption is 10 mA. This LNA offers Output-Third-Order-Intercept-Point (OIP3) of about 14 dBm.

Keywords : Low noise amplifier, Advanced design system

I. Introduction

LNA is an essential device in wireless communication systems such as satellite and mobile communication systems. It is used in receiver as a front-end device as shown in Fig. 1. Providing high gain to the RF signal and adding low noise decreases the overall noise figure of the receiver as suggested by Friis formula,

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \dots + \frac{F_n - 1}{G_1 G_2 \dots G_{n-1}} \quad (1)$$

where F_1 , F_2 , F_3 , and F_n are the noise factors of the first, second, third, and the n^{th} block of the cascaded system. And, G_1 , G_2 , G_3 , and the G_n are the corresponding gains. Noise factor in dB scale is called the noise figure. Decreased overall noise figure is the reason why the use of LNA and its placement in the beginning is preferred in wireless systems.

The position of LNA in a heterodyne receiver is illustrated in the Fig. 1. The receiver mainly consists of antenna, band-pass filter (BPF), LNA, mixer, oscillator, IF Filter, VGA, and ADC.

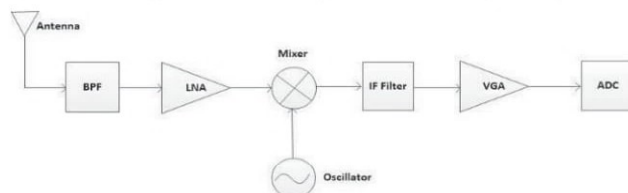


Fig. 1 Block diagram of heterodyne receiver. [1]

This paper includes the design, simulation, and prototype of an LNA operating at 1.5 GHz with bandwidth 100 MHz. The amplifier consists of transistor, resistors, capacitors, and inductors. All the components are SMDs: “Infineon BFP420” Bipolar Junction Transistor (BJT), 0603 capacitors and resistors. Appropriately calculated microstrip lines were used to mimic the inductors.

II. Literature Review

Different papers were reviewed to embark this project work. Most of the LNA designs were found to be based on CMOS technology with cascode structure. The paper [2] presents CMOS LNA design at 5.7 GHz with gain 11.45 dB and noise figure 3.4 dB. Another work at 5 GHz has gain 9.2 dB and noise figure 2.8 dB [3]. The design at 2.4 GHz has comparable gain of 11.2 dB and noise figure of 2.3 dB [4]. The paper [5] compares the performance of CMOS LNA and BJT LNA at 1 GHz. In this paper, the gain and noise figure of CMOS LNA was obtained as 21.64 dB and 1.78 dB respectively with the expense of huge power 23 mW; whereas the gain and noise figure of BJT LNA was achieved to be 14.3 dB and 1.87 dB respectively with the expense of only 4.6 mW. After analysing the performances of all the above LNA designs, I got motivated to design a simple BJT LNA with better performance at different frequency.

III. LNA Specifications

In practice, the specifications are made first before designing a device depending on its use. The important parameters for LNA are stability, gain, noise figure, input return loss, output return loss, and linearity.

A. Stability

LNA must be unconditionally stable for all passive source and load impedances. Stability can be described by μ -factor which is calculated using S-parameters as given below

$$\mu = \frac{1 - |S_{11}|^2}{|S_{22} - \Delta S_{11}^*| + |S_{12}S_{21}|} \quad (2)$$

where

$$\Delta = S_{11}S_{22} - S_{12}S_{21}$$

For amplifier to be unconditionally stable, μ must be greater than 1. The frequency range for stability was chosen from 50 MHz to 10 GHz. [6]

B. Gain, Noise Figure, Input Return Loss, and Output Return Loss

Maximum available gain and minimum possible noise figure of BFP420 at 1.5 GHz are 20 dB and 1.1 dB respectively if the supplied collector current is 10 mA [7]. If input and output ports of LNA are simultaneously conjugate matched then maximum gain is possible. Input should be matched to Z_{OPT} to achieve minimum noise figure [6]. And the resistive components used for stability introduce some additional noise. So, maximum gain and minimum noise figure cannot be achieved simultaneously. The safer margin was kept and minimum gain was specified to be 15 dB and maximum noise figure to be 1.5 dB.

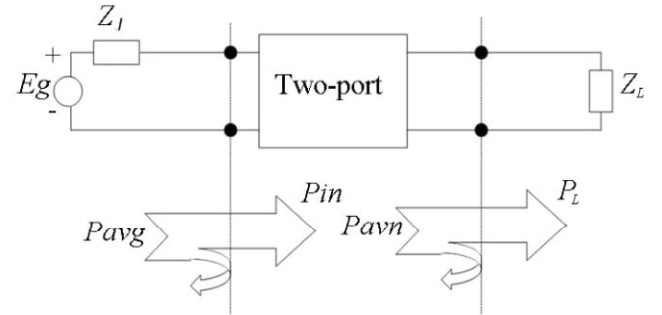


Fig. 2 Power notations in a two-port network.

In Fig. 2, P_{avg} is available power from source, P_{in} is input power to network, P_{avn} is available power from network, and P_L is power delivered to the load. When a signal goes to the input of a two-port network, some of its power gets reflected back due to the mismatch between source impedance and input impedance. Similar is the case in the output port. The reflection of wave at interface can be described in terms of return loss. The value of return loss becomes high if the impedance matching is good. Since input was targeted for noise matching and output was for maximum gain, the input and output return losses were specified to be optimal, that is; minimum of 7 dB and 10 dB respectively.

C. Linearity

For an amplifier to be linear, the plot of output power versus input power must be a straight line with a slope of unity. The linearity persists over a limited range, and then the amplifier response begins to saturate providing less gain. The nonlinearity property produces harmonics and intermodulation products. The harmonic components can be filtered out; where as some of the intermodulation products of closely spaced frequencies

may occur within the bandwidth of the amplifier. They ultimately cause distortion to the signal.

The plot of output power for the first-order and third-order products versus input power in dB is shown in Fig. 3. The output power of the first-order product is linearly proportional to the input power with the slope of unity. On the other hand, the response of the third-order products has a slope of 3. For high input power, both of these lines show compression. When the idealized responses are extended with the dotted lines, they intersect at a point which is known as third-intercept point, denoted as IP3. At this point, first-order and third-order power are equal. The intercept point is specified as either an input power level (IIP3) or an output power level (OIP3).

The third-order intercept point is a theoretical point that is never achieved in practice. The usefulness of this point lies while determining the linearity condition of an amplifier. The higher the output at the intercept, the better is the linearity and the lower is the intermodulation distortion (IMD). Third-order products are the most troublesome nonlinear effects for IMD and hence are studied most often. The IP3 value is an imaginary point that is never reached, as the amplifier will saturate before this condition can occur in practice. [6][8]

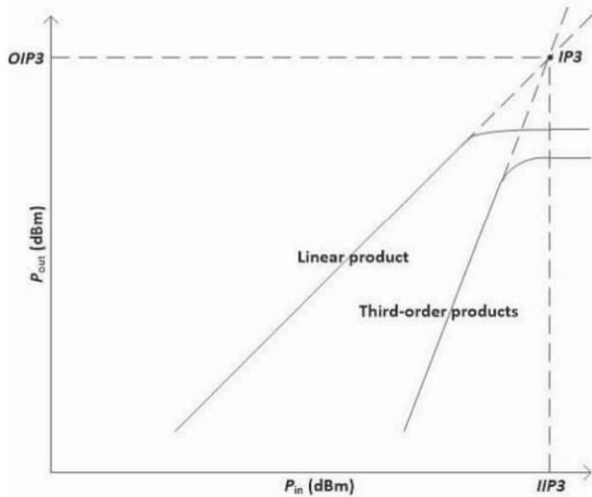


Fig. 3 Third-order intercept diagram for a linear device.

The rule-of-thumb for estimating the OIP3 is

$$OIP3 \text{ [dBm]} \approx 10 \log_{10} \left(\frac{V_{CEO} I_{CO}}{1 \text{ mW}} \right) \quad (3)$$

where V_{CEO} and I_{CO} are the quiescent collector-emitter voltage and collector current of a BJT, respectively, normally selected in the middle of the load line within IV-characteristic [9]. The specified values of V_{CEO} and I_{CO} in this project are 4V and 10 mA respectively. The use of this equation results 16 dBm as the approximated value for OIP3.

The Table I lists all the specifications mentioned in this section.

TABLE I
LNA SPECIFICATIONS

Parameter	Value
Gain (dB)	15 (min.)
Noise Figure (dB)	1.5 (max)
Input Return Loss (dB)	7 (min.)
Output Return Loss (dB)	10 (min.)
OIP3 (dBm)	16

IV. Simulations

Simulation was performed using ADS. Stability issue was sorted out first and other specifications were met after fine tuning of different components.

A. DC Bias Simulations

Current gain (β) of BJT420 model [7] in ADS was determined by using BJT-curve tracer utility in ADS. It was calculated to be approximately 73.

Collector-feedback bias was used in the amplifier design as shown in Fig. 4. The values of collector resistance (R_C) and base resistance (R_B) were calculated using the following equations; provided that the collector current was 10 mA and collector-emitter voltage was 4V.

$$I_B = \frac{I_C}{\beta}, R_C = \frac{V_{CC} - V_{CE}}{I_C}, R_B = \frac{V_{CE} - V_{BE}}{I_B} \quad (4)$$

The calculated values were $R_C = 100 \Omega$ and $R_B = 21.8 \text{ k}\Omega$.

B. S-Parameters Simulations

S-parameter file of BFP420 provided by the manufacturer was used for S-parameters simulations [7]. The circuit diagram is shown in Fig. 5.

1) **Substrate:** Two-sided FR4 board was used as a printable circuit board with the parameters:

substrate thickness of 0.8 mm, substrate relative permittivity of 4.5, copper thickness of 17.5 μm , and loss tangent of 0.01.

- 2) **DC Block:** 0603 SMD capacitors were used as DC blocks. The graph as shown in Fig. 6 was used to determine the value of capacitance that is resonant at 1.5 GHz. It is clear that 22 pF must be the optimal value of capacitance.
- 3) **RF Choke:** RF choke or DC feed is used to prevent RF leakage to DC source but it offers negligible impedance for DC flow. In this project, it is implemented with one 22 pF capacitor and one quarter-wave transformer at 1.5 GHz. The length of the transformer was determined to be approximately 28 mm.

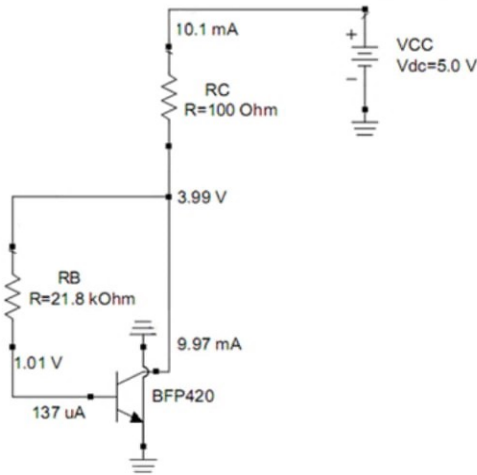


Fig. 4 DC biasing of BFP420.

C. Stability

A shunt resistor (R_{stab1}) and a series resistor (R_{stab2}) as shown in Fig. 5 under the stabilization network were used to make the amplifier unconditionally stable from 50 MHz to 10 GHz.

D. Input and Output Matching

It was fortunate that the input section was already noise matched without adding any matching network as shown in the Smith chart of Fig. 7. Output matching network in Fig. 5 with a capacitor and a shunted inductor was added to maximize the gain. The output section was conjugate matched depicted by the Smith chart as shown in Fig. 8.

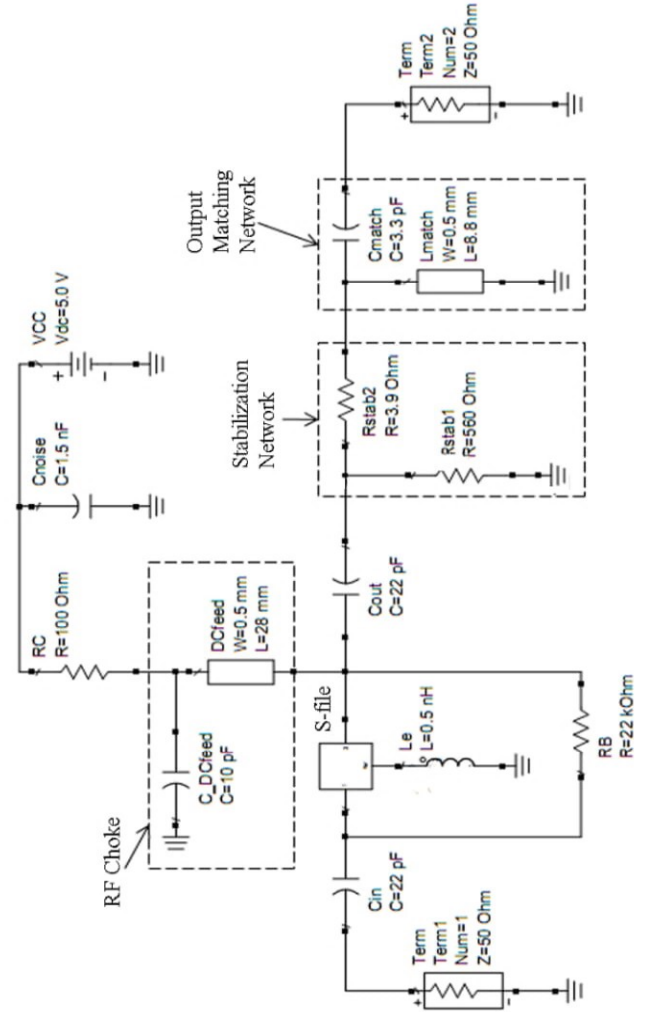


Fig. 5 Circuit diagram of LNA.

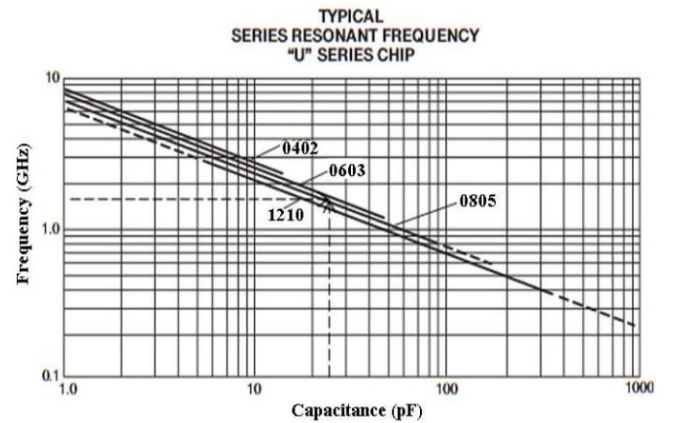


Fig. 6 Capacitor values at resonance. [10]

V. Prototype

After the completion of simulations, a layout was created as shown in Fig. 9. It has size of $27.5 \text{ mm} \times 27.5 \text{ mm} \approx 7.6 \text{ cm}^2$. It was designed such that its size was as small as possible without affecting its performance. The layout was printed on FR4 board and final product was constructed as shown in Fig. 10.

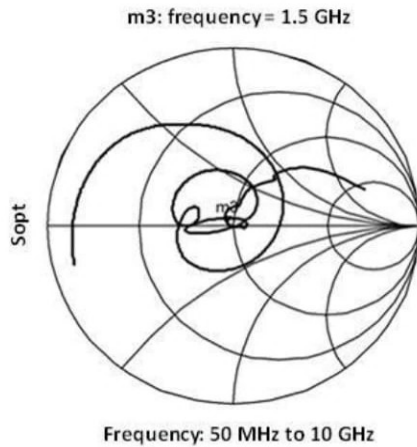


Fig. 7 Plot of Z_{opt} on Z_s line.

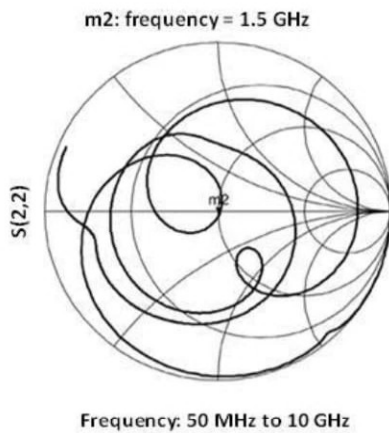


Fig. 8 Plot of S_{22} after matching network.

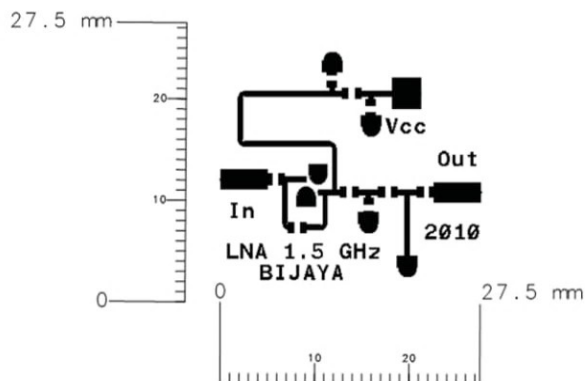


Fig. 9 Layout of 1.5 GHz LNA.

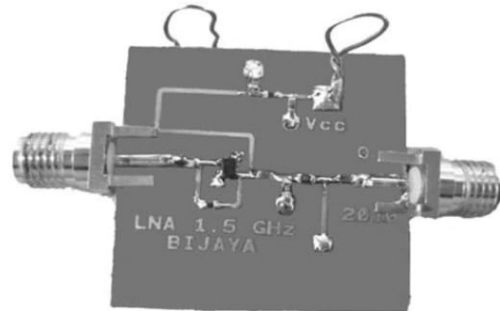


Fig. 10 Prototype of 1.5 GHz LNA.

VI. Results

This section presents the simulations results and the results from the measurements of the LNA prototype. To get the proper DC bias point of the prototype, the value of base resistor had to be increased to $33 \text{ k}\Omega$ from its simulated $22 \text{ k}\Omega$. To get the parameters' values close to the simulated results, the output coupling capacitor C_{out} had to be decreased to 2.2 pF and capacitance of DC feed to 10 pF .

The VNA was used to measure the stability factor, gain, input return loss, and output return loss of the LNA. Similarly, the noise figure meter was used to determine the noise figure. And, the OIP3 measurement was carried out with the help of spectrum analyzer. The simulated and measured plots have been included in the same figure so as to ease the comparison analysis.

The plot of stability factor is shown in Fig. 11. This depicts clearly that the LNA is unconditionally stable within the range of 50 MHz to 10 GHz.

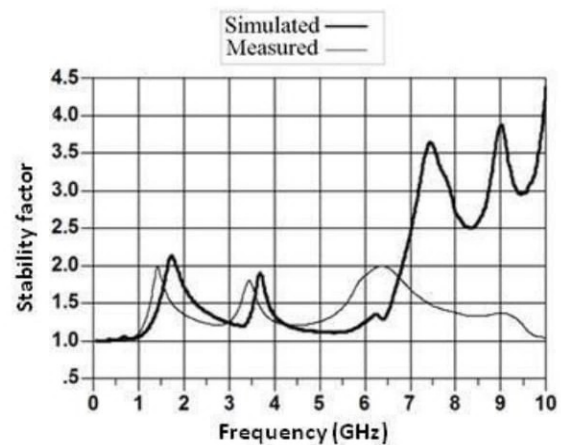


Fig. 11 Stability factor.

The results of gain, noise figure, input return loss, and output return loss are presented respectively in Fig. 12, 13, 14, and 15 respectively. The values of these parameters have been listed in Table II. In the table, 'S' represents 'simulated' and 'M' represents 'measured'.

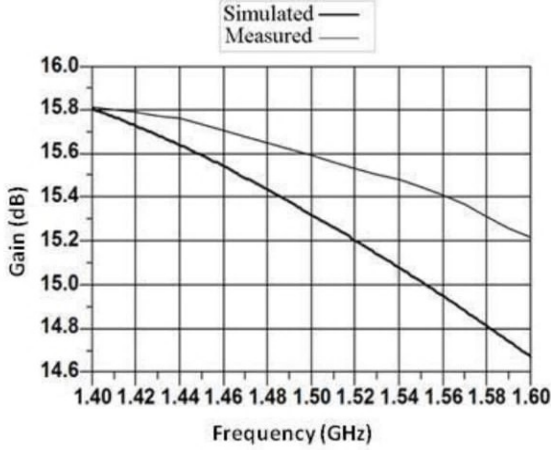


Fig. 12 Gain of LNA.

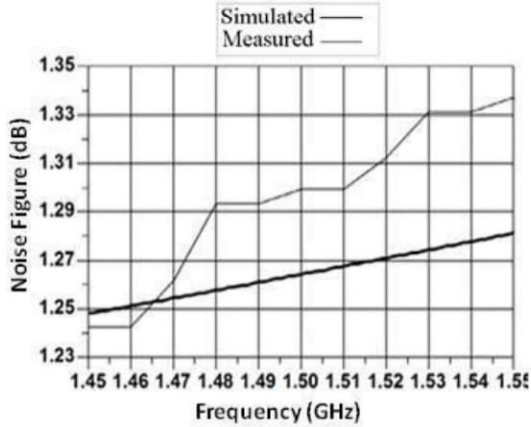


Fig. 13 Noise figure of LNA.

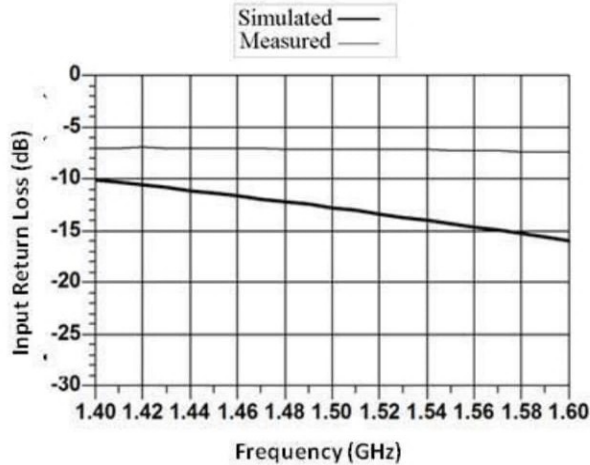


Fig. 14 Input return loss of LNA.

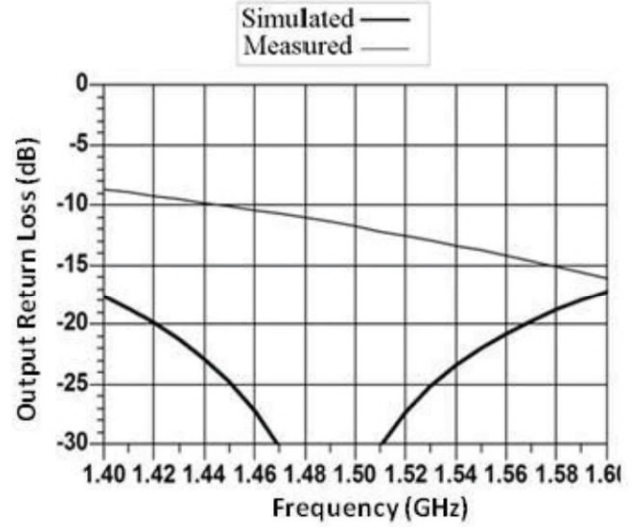


Fig. 15 Output return loss of LNA.

TABLE II
Results

Parameter	1450 MHz		1500 MHz		1550 MHz	
	S	M	S	M	S	M
Gain (dB)	15.6	15.7	15.3	15.3	15	15.6
Noise Figure (dB)	1.25	1.24	1.26	1.3	1.2	1.34
Input Return Loss (dB)	10	7	12.5	7.2	14	7.3
Output Return Loss (dB)	25	10	34.5	12	20	14

While comparing the results between simulations and measurements, we do not see much difference in gain and noise figure. On the other hand, the difference is prevalent for input return loss and output return loss. This might have resulted due to change in the value of coupling capacitor in the output section. However, both the simulated results and measured results have fulfilled the specified values.

Nonlinear model of transistor was used for the simulations of OIP3. The simulations results are shown in Fig. 16 for three frequencies: 1450 MHz, 1500 MHz, and 1550 MHz.

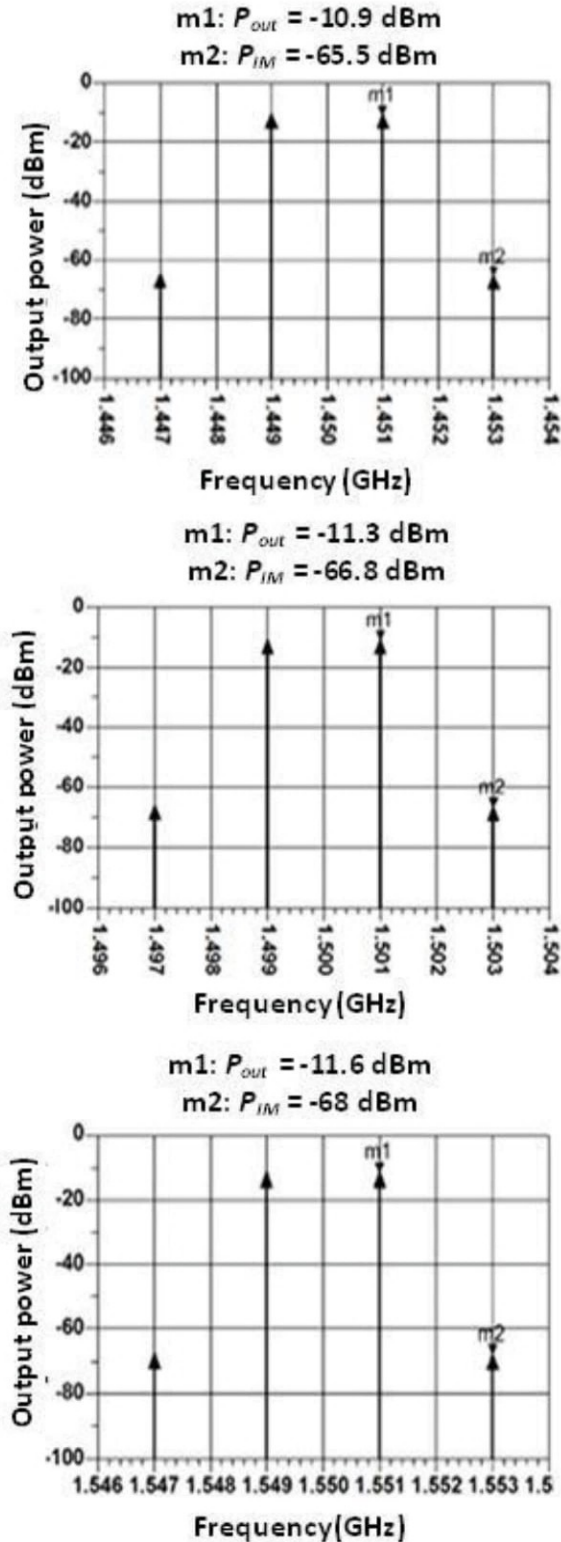


Fig. 16 Simulations results of OIP3.

Here, P_{out} is the fundamental output power and P_{IM} is the third-order intermodulation power. OIP3 can be calculated using

$$OIP3 = P_{out} + (P_{out} - P_{IM})/2 \quad (5)$$

Two signal generators and one spectrum analyzer were used to measure OIP3 at 1450 MHz, 1500 MHz, and 1550 MHz. The input power level was set at -20 dBm and fundamental power (P_{out}) and third-order intermodulation power (P_{IM}) were measured. The necessary data and the calculated OIP3 are tabulated in Table III.

TABLE III
OIP3 Calculations

Parameter	1450 MHz		1500 MHz		1550 MHz	
	S	M	S	M	S	M
P_{out} (dBm)	-10.9	-9	-11.3	-9.2	-11.6	-9.6
P_{IM} (dBm)	-65.5	-55	-66.8	-57	-68	-58.3
OIP3 (dBm)	16.4	14	16.45	14.7	16.6	14.75

The simulated OIP3 has minimum value of 16.4 dBm, whereas, only 14 dBm has been recorded as the minimum measured OIP3. So, the actual value differed from the specified one by 2 dBm.

VII. Conclusion

The specifications were prepared before designing the LNA at 1.5 GHz for the bandwidth of 100 MHz. The SMD components were used with BFP420 BJT transistor and 0603 resistors and capacitors. The inductors were implemented using the properly calculated transmission lines. The amplifier was simulated, and proper tuning of the components was made to meet the specifications. The LNA was fabricated on the FR4 board. By changing the values of few components, all the specified values of the parameters were obtained. The prototype is unconditionally stable from 50 MHz to 10 GHz. The minimum gain of 15.3 dB, the maximum noise figure of 1.34 dB, the minimum input return loss of 7 dB, and the minimum output return loss of 10 dB were obtained after measuring the LNA prototype. The minimum value of OIP3 was obtained to be 14 dBm. Except OIP3, all the parameters met the specifications. Such design can be used to develop LNAs at desired frequencies for mobile communication, satellite communication, and other forms of wireless communication where higher gain is required with the addition of very less noise. The gain can be increased further with multistage configuration.

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A Study of Reservoir Volume and Its Inundated RMs of Budhi Gandaki Hydropower Project with Respect to Dam Height Variation

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Abstract

Water resources are the most important natural resources as they are renewable natural resources and also abundantly available in the context of our country. It has huge number of large rivers and streams which has got very high potential of generating hydroelectricity. Construction of any civil engineering structure is not only fully about the design on which it based on but also the impact it does to the surrounding of it. Huge civil engineering structure like Budhi Gandaki hydropower project is a proper demand for the country like ours. Budhi Gandaki Hydropower project site is west of Kathmandu having E576261 and N3079050. The project has the huge potential of generating about 1200 MW which is obtained by constructing a high rise dam height of 263m. In “A Study of Reservoir Volume and Its Inundated RMs of Budhi Gandaki Hydropower Project with Respect to Dam Height Variation”, the analysis was done with the help GIS to find out various inundation nature of the reservoir at dam height variation and even DEM of the Nepal was used to find the catchment area, inundation area, inundation volume and affected RMs of the project.

Keywords : Budhi Gandaki, Hydropower

I. Introduction

Nepal is situated between latitudes of 26° 22' to 30°27' north and between longitudes of 80° 04' to 88° 12' east [1] bordering India on east, west and southern side and Tibetan region of China. The east west highway of the country is about 800 km, roughly parallel to Himalayan axis, and the average

north-south width is 140 km. The rivers/streams of Nepal flow through the entire mountain chain of Himalaya. Approximately 6000 rivers and rivulets [5], about 45000 km in length with total drainage area of 194,471 km² [6] flow through Nepal, of which 76% is contained within Nepal [2]. Sum of these rivers and streams constitute the major river basins like Koshi in the east; Gandaki, Bagmati, Kamala, Budhi Gandaki in the middle and Arun, Rapti and Mahakali in the west join Ganga River system draining the southern slope of Himalaya. Most of the major perennial rivers and sum of these tributaries originate in the high altitude in snow and glaciers while others have springs as antecedent and have cut deep gorges at their catchment areas lay on the northern slope of Central Himalaya i.e. Gandak, Koshi, Karnali and Mahakali. The unique topographic features of Nepal are one of the two main reasons that make country so rich with water power resources.

Nepal's rivers are very steep. The average bed slope for the main rivers varies from 0.6% to 6.8% and for the small rivers from 1.0% to 12.4% [3]. Although Nepal is rich in water resources, the proper utilization of hydropower potential is below par. In Nepal, electricity is available to limited percentage of people in urban and semi urban areas. Hence most Nepalese living in villages use firewood for their energy requirements. Utilizing woods for fire, construction of homes and other purposes are the major causes of deforestation and environmental degradation. On the other hand, the growing industrial sector needs reliable energy supply, which can only be fulfilled by hydropower in a country like Nepal.

A. Purpose of Research

Nepal has a huge potential of generating electricity. In spite of that, Nepal is still lacking power; as a result Nepal is still buying electricity from India to fulfill its need. Although Nepal has developed its first hydropower project about a century ago, the development pace of its hydropower development is not as it was expected and needed. Because of that, severe load shedding is unavoidable and becomes a part of Nepalese people.

There are various reasons which reflect the purpose of this research and they are as follows:

- Impacts of inundation in this area are essential element to be studied so as to get the proper view of the project.

- To know the reservoir volume and its inundated RMs due to dam height variation.
- To prepare inundation map and catchment delineation

Recent advances in computer technology have offered many benefits to field of water resources especially due to emerging of geographic information system (GIS). GIS in conjunction with hydropower model can be used in a variety of hydrologic application like delineating the drainage pattern in a watershed. Especially in Hydropower sector the fewer example of GIS application has been used. The main basis of study is the couple the GIS with the modelling tool to assess the hydropower potential of the river reach.

II. Description of Study Basin

Budhi Gandaki Hydropower Project is a storage type project located in Central/Western Development Region on the Budhi Gandaki River of Nepal. This project was identified during the Gandaki Basin Study in late 70's [4]. In 1984, a prefeasibility study of the project was prepared. The prefeasibility study of the project has recommended 600 MW capacity plant with Full Supply Level 520 masl [4]



Fig.1 View of Budhi Gandaki River

A Location and Accessibility

The project lies in Gorkha and Dhading districts in Western/ Central Development Region of Nepal. The project site is accessible through Benighat on Prithvi Highway (Kathmandu - Pokhara). From Benighat, a pedestrian suspension bridge can be used to cross the Trishuli River and access the Dam and Powerhouse site both of which are at a distance of about 2 km from the road head. The Budhi Gandaki Hydropower Project dam is located at the cross-junction of Ghyalchok RM of Gorkha District and Salang RM of Dhading District demarcated by Budhi Gandaki River whereas powerhouse is located on the left bank of the River on Salang RM at Kelleri village.



Fig. 2 Location of budhi gandaki hydropower project

Narayangaht and Pokhara are about 69 km and 123 km respectively to the south west and west of the Dam site. The right abutment of the Dam locates on the fair weather Benighat – Arughat road approximately 3 km from the Prithivi Highway. A two lane motorable bridge across Trishuli River connects Benighat – Arughat Road with the Prithivi Highway.

III. Methodology

A. Study approach and process

Budhi Gandaki Hydropower is the most prestige project of Nepal. The location of our site is Benighat, Dhading and the geographic location of the site is E576261 and N3079050. [4] We in the process wanted to analysis the reservoir volume and its inundation area due to the dam height variation.

As it says, the reservoir has the capacity of producing 1200MW [4] power but we also wanted to confirm that the reservoir runs all day or variate in time as the demand on wet and dry season. We went to the office of Budhi Gandaki Hydropower project situated

on Benighat and interviewed the employee. Data regarding the land accusation process were collected on the office as well. Various help of secondary data were taken and reports from various agencies are used to get to the conclusion.

B. Data Collection

The field visit was conducted on Budhi Gandaki Hydropower dam. The vicinity at the Budhi Gandaki Hydropower dam upstream was the area of study focusing the different features within the area. For Primary Data collection, the use of GPS Device was used for taking the coordinates at various points. Digital Elevation Model (DEM) and the land-use map have been used for the study as the secondary data collection. The team also collected information regarding the project from different agencies and organization.

C. Data Analysis

The details of different points and features around the DAM site were taken by using the GPS Device. ESRI GIS 10.4 was used for the analysis i.e. simulation and estimation modelling of the submerged area on the catchment on various elevation of the Budhi Gandaki Hydropower Dam. GIS is one of the most powerful mapping software with features such as estimation and modelling and above all, integration of the database to the digital map. And also for the easy accessibility of the software we used GIS as the major tool for analysis.



Fig. 3 Site visit and use of gps for data collection

The location of the possible households was obtained with the help of GPS and so does the location of the dam site. The analysis was done with the help GIS to find out various inundation nature of the reservoir at dam height variation. And even DEM of the Nepal was used to find the catchment area, inundation area, inundation volume and affected RMs of the project.

IV. Result and Discussion

With all the analysis, we can conclude that for every variation of dam height the changes happen on inundation area, inundation volume and on affected

RMs from the inundation. As more the height more the values of the respective above features and vice versa.

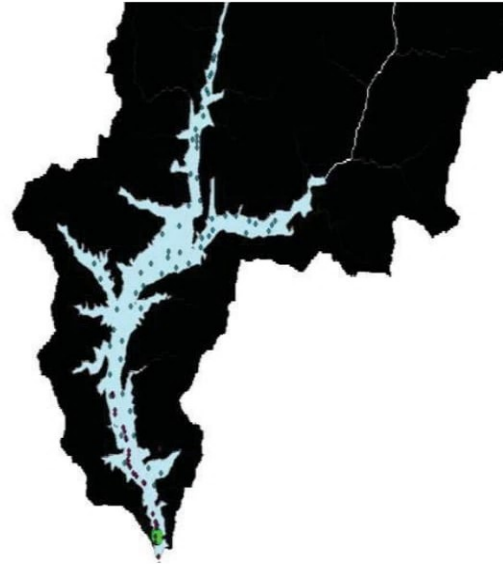
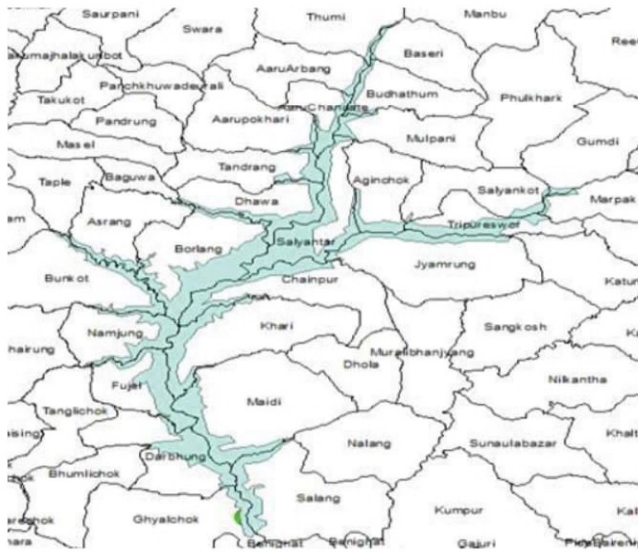


Fig. 4 Effected RMs at 263 m dam height

Inundated area = 96046032.537 m²
Reservoir volume = 833726757704 m³

Effected Project RMs of Gorkha district are Ghyalchok, Bhumlichok, Phujel, Namjung, Bungkot, Asrang, Borlang, Dhawa, Tandrang, Aarupokhari, Aaru Chanaute, Aaru Arbang and Thumi; and Salang,

Maidi, Khari, Chainpur, Jyamrung, Marpak, Salyankot, Tripureswor, Aginchok, Salyanta, Mulpani, Budhathum and Baseri are RMs of Dhading district.

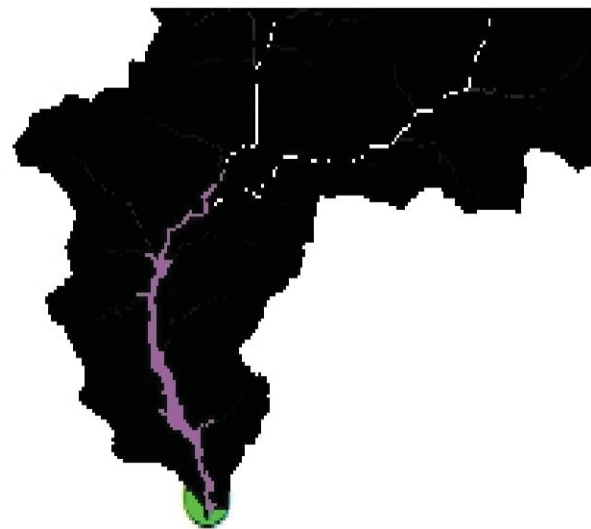
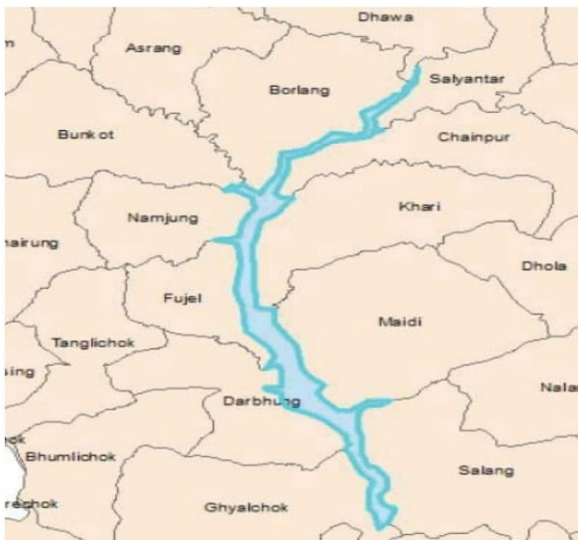


Fig. 5 Effected RMs at 100m dam height

Inundated Area = 13334782.55 m²
Reservoir Volume= 1087927616.04 m³

Effected RMs of Gorkha district are Ghyalchowk, Darbung, Fujel, Namjung, Bunkot and Borlang; and

Salang, Maidi, Khari, Chainpur and Salyantar are RMs of Dhading district.

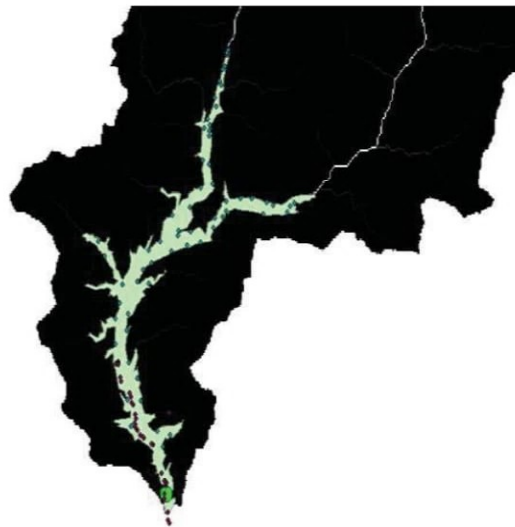


Fig. 6 Effected RMs at 150m dam height

Inundated Area Covered: 47247949.378 m²
Reservoir Volume: 190691348720.68 m³

Effected RMs of Gorkha district are Ghyalchowk, Darbung, Fujel, Namjung, Bunkot, Borlang, Dhawa

and Salang, Maidi, Khari, Chainpur, Salyantar and Jyamrung are RMs of Dhading district.

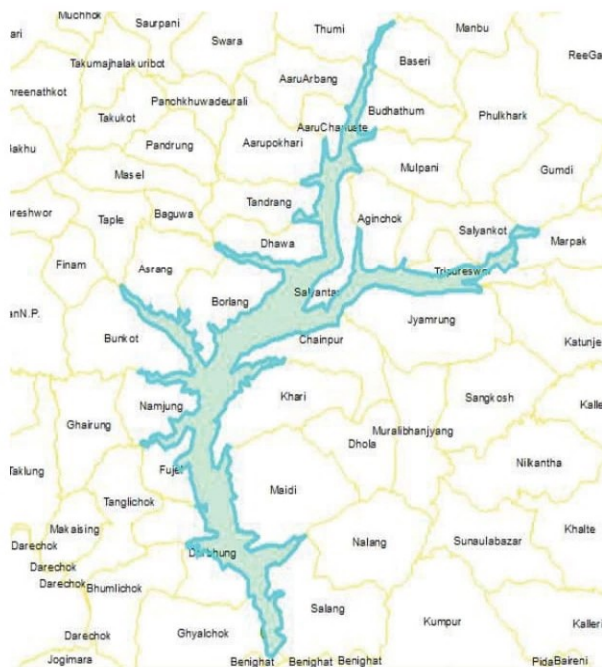


Fig. 7 Effected RMs at 250m dam height

Inundated Area: 87009816.85 m²
Reservoir Volume: 680622061175.36 m³

Effected RMs of Gorkha district are Ghyalchok, Bhumlichok, Phujel, Namjung, Bungkot, Asrang, Borlang, Dhawa, Tandrang, Aarupokhari, Aaru Chanaute, Aaru Arbang and Thumi; and Salang, Maidi,

Khari, Chainpur, Jyamrung, Marpak, Salyankot, Tripureswor, Aginchok, Salyantar, Mulpani, Budhathum and Baseri RMs of Dhading district.



Fig. 8 Effected RMs at 300m dam height

Inundated Area: 119103476.69 m²
Reservoir Volume: 1297882734045.05 m³



Effected RMs of Gorkha district are Ghyalchok, Bhumlichok, Phujel, Namjung, Bungkot, Asrang, Borlang, Dhawa, Tandrang, Aarupokhari, Aaru Chanaute, Aaru Arbang, Thumi, Finam, Baguwa and Salang, Maidi, Khari, Chainpur, Jyamrung, Marpak, Salyankot, Tripureswor, Aginchok, Salyantar, Mulpani, Budhathum, Baseri and Nalang RMs of Dhading district.

TABLE 1

TOTAL AFFECTED RMs AND HOUSEHOLDS WITH RESPECT TO DAM HEIGHT VARIATION

Dam height	Gorkha		Dhading	
	RM	Household	RM	Household
100	6	1754	5	2492
150	7	2245	6	2773
250	13	3821	13	4296
263	14	3831	13	4296
300	15	5081	14	7031

TABLE 2

COVERAGE OF THE AREA BY THE CHANGE IN ELEVATION OF THE DAM

SN	Height of dam(m)	Area (m ²)	Volume(m ³)
1	100	13334782.55	1087927616.04
2	150	47247949.38	190691348720.68
3	250	87009816.85	680622061175.36
4	263	96046032.54	833726757704.00
5	300	119103476.69	1297882734045.05

V. Conclusion

With all the results and analysis, we conclude that variation of dam height changes inundation area, inundation volume and affected RMs. With the construction of the project various impacts will be developed in a positive and negative way. We can surely say that every measure is taken to make sure the negative impacts are minimized such as

compensation and relocation plan are in the way of implementation. Most of the people are happy that the country is developing and building the biggest project till date but some people are not due to lack of timely implementation of decision regarding relocation and compensation. The inundation of the reservoir affects the livelihood of the people and affects them mentally and challenges them on the future prospect of their lives. The demonstration of reservoir volume and its inundation area with variation of the dam height help to manage relocation of affected people of the project.

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Prospect of Floor Heating System in Residential Buildings in Kathmandu Using Compound Parabolic Concentrator (CPC)



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Abstract

Underfloor heating system is more suitable for space heating because of its unique temperature gradient profile. If solar radiation can be utilized for heating of water in radiant floor heating system, the cost of electricity can be reduced. Because of the sufficient availability of solar radiation in Kathmandu Valley during winter season, underfloor heating with solar water heating can be a viable technology for residential buildings. So this paper is focused on identifying suitable system for domestic radiant floor heating system. Compound parabolic concentrator (CPC) water heating system is more suitable for heating water because tracking system is not required and sufficient water temperature can be achieved. It is also found that more studies are necessary to make the system cost effective and suitable for the residential buildings in Kathmandu.

Keywords : *Compound parabolic concentrator, underfloor heating system*

I. Introduction

Winter season in Kathmandu is regarded as an uncomfortable period by its residents. The average minimum temperature for November, December, January and February is calculated as 7.8°C, 3.7 °C, 2.4 °C and 4.5°C respectively [1]. During the winter season, common modes of room heating system used by the people in Kathmandu Valley are split air-conditioner, kerosene heater and halogen heater. One of the disadvantages of these types of heating systems is their inability to heat the floor. Cold floor adds to the discomfort level since sitting on the floor is still a common activity among the people in Kathmandu. So there is a scope for innovation in suitable room heating system for residential buildings in Kathmandu.

Underfloor heating system (also known as radiant floor heating system), a common process in other part of the world, can be an alternative heating system to combat the effect of cold floor. If underfloor heating system is run by solar energy, greenhouse gas emission and cost of electricity bills can be reduced. With annual average solar energy of 5.19 kWh/m²/day in Kathmandu [2], there is an opportunity of utilizing solar energy for domestic space heating. So this paper examines the possibility of adopting solar powered underfloor heating system in residential buildings in Kathmandu.

II. Underfloor Heating

The origin of underfloor heating can be traced back to 900 BC – 800 BC in Korea. That time, the system used a fireplace and a smoke tunnel [3]. Modern radiant floor heating system works by heating the floor with the help of hot water pipe network concealed in the floor. Water running through the pipe is heated in boiler or in any other way. The thermal mass of the floor absorbs heat from the hot water running through the pipe and transfers heat constantly for a long time as shown in Fig. 1. Use of modern radiant floor heating system is growing since it is an energy efficient system compared to the conventional all-air system. Yet, it is used less than other conventional heating system [4].

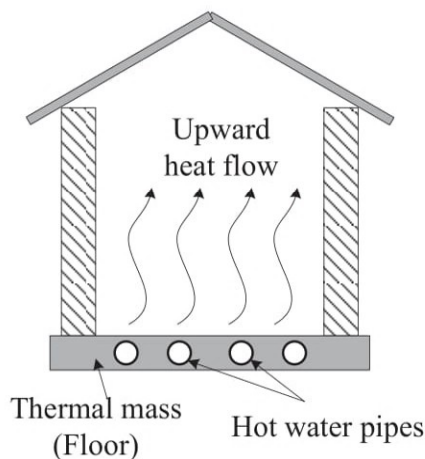


Fig. 1 Working mechanism of radiant floor heating system

Heat transfer in radiant system involves heat conduction through wall, heat convection between floor and room air and heat radiation between floor and surrounding areas [5].

Major advantage of floor heating system is its temperature gradient profile. Since hot air flows upward, temperature is higher near the floor. The temperature decreases with height and reaches minimum at ceiling level. When the temperature profile of various heating system are compared (Fig. 2), it can be observed that the radiant floor heating system closely match the optimum temperature profile [6]. The significance of temperature profile of radiant floor heating system is that our body is in contact with the higher temperature range compared with other heating system.

Apart from that, for countries where sitting on the floor is common for eating, sleeping and family gathering, underfloor heating provides an extra comfort since the floor remains warm [3].

The major disadvantage of floor heating system is higher investment cost compared to other heating system. If planning, design and installation of radiant heating system are done parallel with building construction, initial cost related to heating system can be reduced up to some extent. However, it can be installed in existing buildings with some modification of building. Another disadvantage of radiant floor heating system is that the performance of the system depends on the floor construction material. Thalfeldt et al. [7] have pointed out that according to several studies, heat transfer in underfloor heating significantly depends on floor material such as tile and laminated wood.

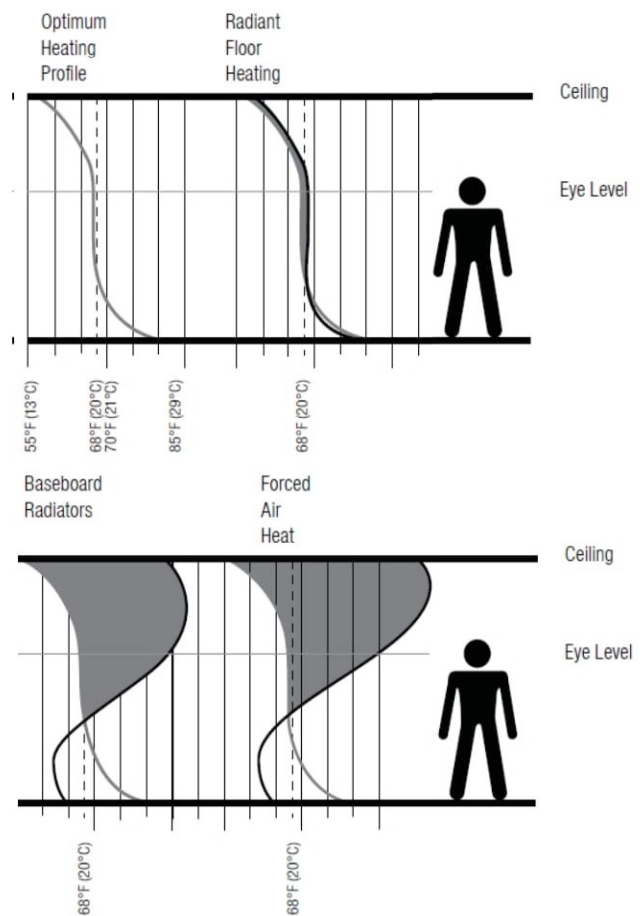


Fig. 2 Temperature profile of various heating system [6]

Water heating system (Fig. 6) consists of evacuated all-glass solar collector with simplified CPC fitted underneath the tube. Locally available evacuated tube can be used for this purpose. Simplified CPC can be fabricated with sheet of stainless steel mirror. Hot water from the solar heater is collected in hot water tank. Hot water is then circulated to the room with the help of water pump. The cold water coming out from the room is sent to cold water tank which, in turn, is feed to solar collector.

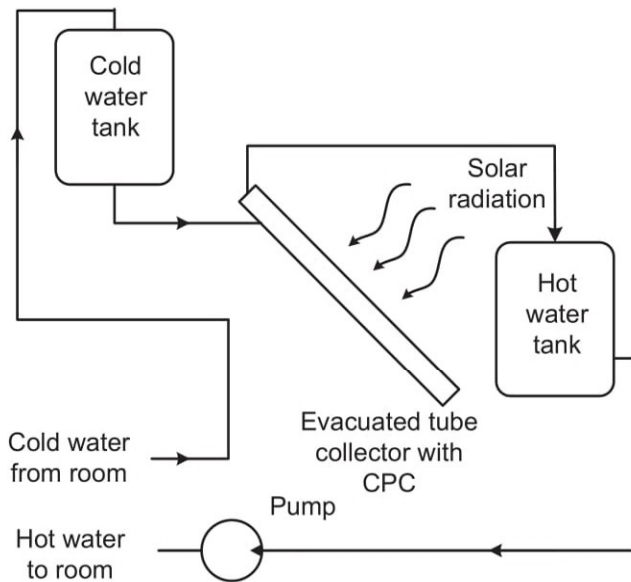


Fig. 6 Heating system

V. Design Parameters

Followings are the parameters that should be considered while designing above system.

- Heating load of the room which depends on parameters such as number of outside wall and its material, direction of wall, purpose of the room, and number of windows.
- Required floor insulation.
- Capacity of hot water storage tank for use after the solar radiation is not available and flow rate of water.
- Amount of heat retained by the thermal mass of the floor and number of hours that heat can maintain the room in desired temperature once the stored hot water is pumped out.

- Pipe layout and spacing between pipes.
- Using electrical heating as a backup system.

VI. Further Study

The major challenge of the proposed model is heating the room during night and at early morning since solar energy is not available at these durations. Moreover, heating load is higher at these times. The source of heat for these durations is heat stored in thermal mass of the floor and hot water stored in the tank. Thickness of the floor and size of the tank cannot be increased independently. The other option to keep the room heated is minimizing the heat loss through the room. Reduction of heat loss from the room largely depends on the construction materials. Existing construction materials may not be suitable for curbing the heat transfer. So, one of the future study areas can be finding out alternative building construction materials and construction practices. Apart from making the system technical feasible by proper design and selecting appropriate construction materials, another aspect is carrying out the life cycle cost analysis and heating cost comparison between fossil fuel, electricity and solar to check for the financial viability of the system.

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Economical Design of Sewer Line in Flat Terrain: A Case Study of Rajapur Sewerage System



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Abstract

Design of sewer line in flat terrain is a great challenge due to high excavation depth involved in laying a sewer line required for maintaining minimum velocity, slope and clear cover. Sewer design presented in this paper is result of sewer modelling software Bentley SewerCAD V8i. Estimation and cost analysis of a sewer system shows cost is directly related to the excavation depth. For economically efficient design of sewer line in a flat terrain of Rajapur-Bardia, sewer is designed in the gentle slope and flushing tanks are provided at sections where velocities are less than the minimum value recommended by Codes. Design and cost estimation of sewer network of 4.554 km with and without use of flushing tank are presented in this paper and two major benefits - cost and low invert level of outfall from ground surface elevation are achieved with flushing tank provision.

Keywords: Sewer line, Flushing tank, economic design

I. Introduction

Sewer is a basic infrastructure in any society. Nepal is facing rapid urbanization with many infrastructures planned to be constructed. In recent years, water, sanitation and hygiene sector in Nepal is receiving great attention as Nepal is now one of the few countries in the world where citizens' access to safe water and sanitation services and the right to live in a healthy and clean environment have been explicitly mentioned as the fundamental human rights in the new Constitution.

Rajapur municipality is an expanding municipality. Core area of the city has already faced saturated density with appreciable waste water being generated. The situation of sanitation in the selected wards of Rajapur is hopeless as there is direct discharge of sewage into natural drain or in some cases there are poorly designed septic tanks. This has serious impacts on environment and health. The rapidly growing population on the study site is a major challenge in the near future. It is thus important to address the worst practice of sanitation happening in the study site and proper means of treatment and disposal to be devised.

However, owing to the large cost in laying a sewerage network it is therefore important to design sewer in a most possible gentle slope i.e.,

mimicking natural ground slope and offsetting problem of maintain velocity by provision of flushing tank.

II. General description of the study area

Rajapur is a municipality in Bardiya District in the Bheri Zone of South-Western state 5 of Nepal. It is situated at $28^{\circ} 26' 0''$ North latitude $81^{\circ} 5' 0''$ East longitude and 130 meters elevation above the mean sea level. Rajapur is small municipal in Nepal, having about 14000 inhabitants. The Karnali River flows from North-East to South-East direction. Landscape of the project area is flat. Most of the project area includes settlement area and agriculture land. Soil in the project area is moderately fertile. In this municipality, population has been increasing in a high rate (Geometric growth rate of +2.1% from year 2001-2011) [1], [2]. However, poor management and haphazard disposal of sewage on natural drain is degrading beauty of city with alarming threat on health to locality residents.

III. Sewer Network Layout

The network of sewer line in the project area is so selected that the total distance of the trunk line from the farthest point to the outfall point is least possible to reduce excavation depth. Based on this condition, the network is designed with five trunk lines with several laterals draining into it. Another factor considered in network design is avoidance of bends to minimize obstruction of flow during lean season.

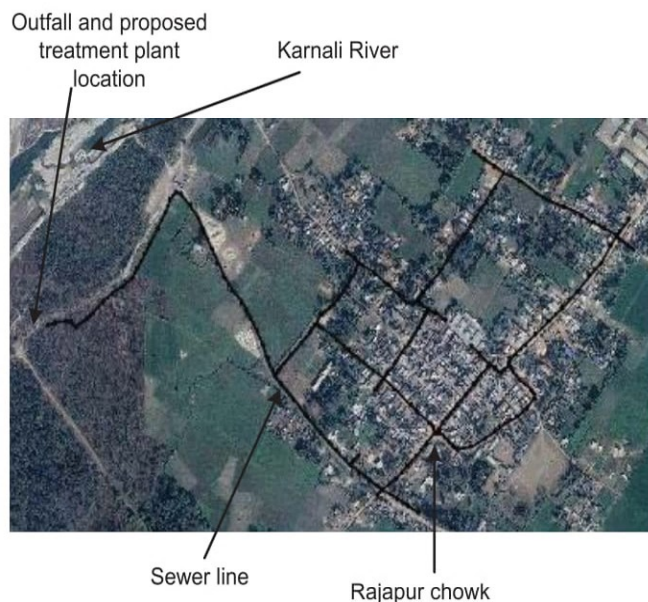


Fig. 1 Sewer layout

IV. Objective function

Whenever a sewer system is to be designed the important parameters that are to be considered are cost optimal and sufficient head availability from outfall point to the treatment plant units. The topography of the land is challenging in terms of maintaining head at the proposed treatment plant site. Therefore objective of this design is to minimize excavation depth as much as possible and at the same time selection of moderate sized sewer pipes to reduce total cost of project.

V. Methodology and Design Criteria

Flow in sewer is unsteady in nature and under atmospheric pressure. Basic hydrodynamic equation used in simulating flow under the model platform is Gravity friction method-Manning's formula [3]. The sewer channels to be designed are prismatic with circular cross section and concrete material.

The hydraulic parameters such as flow, depth and velocity are representative of the middle section of channel [3].

The sewer line is designed for dry weather flow, at 25% full discharge condition which helps in accommodating storm water of average rainfall. It is assumed that only certain part of the storm water may enter to the sewer line as there is separate provision of draining street storm water by open drainage provided on the road edges. So the system can be considered as a partially combined. Design steps and constraints are presented in Table I.

TABLE I

Design steps and constraints

Design steps	
1. Calculation of Sanitary sewage [4]	
• Sewage factor: 70%	
• Peak factor: 3	
• Commercial factor: 10%	
• Per capita water demand: 85 lpcd	
• Ground water infiltration: 0.1 lps/ha/day	
• Design period: 20 years	
2. Manhole(MH) spacing	
Manholes are placed when there is change in alignment, gradient, diameter of sewer, head of every trunk line and laterals. Since the terrain is flat, Manhole spacing is maintained within 30 m at most so that obstruction caused due to siltation can be easily handled [5].	

3. Calculation of ground slope from the survey data.
4. Selection of Sewer pipe class and Diameter [6].
5. Selection of slope in sewer section from upper MH to lower MH. • Maximum slope: 1/10 [7] • Minimum slope: 1/1000
6. Velocity constrain: V_{min} : 0.45- 0.6 m/s [8], V_{max} : 3m/s [7].
7. Average available clear cover: Minimum 2m.
8. Percentage full constrain: 25%
9. Provide drop manhole for more 0.6 m elevation difference [5].

VI. Results and discussions

Design of sewer network on SewerCAD platform is efficient as the model has several options. After setting design constraints mentioned in Table I, SewerCAD automatically design all parts of the gravity sewer network. To analyse what-if situation under the introduction of flushing tank, two scenarios are developed. Design without flushing tank and design with flushing tank. In both alternatives, sewer pipe routes are same with 175 manholes, out of which 8 manholes are drop type, introduced to reduce earth work in excavation along branch pipes for cost effective design.

The result of two scenarios are estimated and rate analysis is done based on the District rate of Fiscal year 2074-2075 [9]

TABLE II
Comparison of results

Design Results	Without flushing tank provision	With Flushing tank Provision
Flow velocity	V_{min} -0.45m/s and V_{max} -0.74m/s	V_{min} -0.2m/s V_{max} -0.6m/s
Sewer Pipe class and Size	NP3-300,400,500	NP3-300,400,500,600
Invert level of Outfall	4.8m	1.8m
Total Project cost in NPR	102,202,919.71	71,915,952.92

A. Maintenance of flow velocity

1. *Design without flushing tank provision:* Under this option, design is performed with maximum slope as 1% and minimum slope as 0.2%. All sewer lines meet V_{min} as stipulated

in Table II. There is no condition of exceeding of V_{max} as the maximum velocity attained is only 0.74m/s. This design can be considered safe in terms of problem that comes when velocity limits are not maintained such as corrosion and erosion.

2. *Design with flushing tank provision:* In this case, design is performed under more flat slope ranging from 1% to 0.1%. Result showed that starting points of sewer lines do not meet minimum velocity so flushing tanks are provided on the critical sections.

B. Sewer pipe size

1. *Design without flushing tank provision:* NP3-Hume pipe with diameter 300mm, 400mm and 500mm
2. *Design with flushing tank provision:* NP3-Hume pipe with diameter 300mm, 400mm, 500mm and 600mm

C. Invert level of outfall point

1. *Design without flushing tank provision:* In this option, there is excessive excavation volume and the invert level of outfall point is 5.3 m below ground level which is below the bed level of Karnali River.
2. *Design with flushing tank provision:* This design option yields minimum possible excavation depth with invert of outfall point being 2.4 m below ground level.

D. Total project cost

1. *Design without flushing tank provision:* Calculation based on norms and approved district rate resulted total project cost to be NPR 102,202,919.71
2. *Design without flushing tank provision:* Under this provision the total estimated cost of project is NPR 71,915,952.92

E. Trade off Analysis:

Analysis for optimized sewer network involves cost effective, technically sound and minimum excavation depth at the outfall point.

Examination of result of sewer network performed on Bentley SewerCAD under two alternative scenarios gave insight that option one i.e. design without flushing provision only has one advantage of maintain minimum velocity over design with flushing tank option. Moreover, the problem of unmet minimum flow velocity is pronounced only during lean season flow and this can be prevented by providing flushing tanks of appropriate sizes. The major disadvantage of option one is that invert level at outfall point 4.8 m below ground level. In case of flat terrain, ground water level is quite high so high depth of excavation is directly related with the problem of ground water intrusion which hampers workmanship.

Therefore, comparison of benefits under this two design criteria shows option two i.e., design with flushing tank provision, as the most economical design.

VII. Conclusions

Design of sewer network in Bentley SewerCAD is extremely efficient as the platform allows design under different criteria and scenarios. With help of this model, Rajapur sewer network is designed and analysis showed how to design optimal sewer network in flat terrain that meets technical specification and at the same time is cost effective.

Flat terrain was the main challenge for design. It is thus important to look for several options and introduce ancillary structures that will offset problems caused by design constrain limitations.

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Automated News Classification using N-gram Model and Key Features of Nepali Language

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Abstract:

With an increasing trend of publishing news online on website, automatic text processing becomes more and more important. Automatic text classification has been a focus of many researchers in different languages for decades. There is huge amount of research repository on features of English language and their uses on automated text processing. This research implements Nepali language key features for automatic text classification of Nepali news. In particular, the study on impact of Nepali language based features, which are extremely different than English language, is a more challenging because of the higher level of complexity to be resolved. The research experiment using vector space model, n-gram model and key feature based processing specific to Nepali language shows promising result compared to bag-of-words model for the task of automated Nepali news classification.

Keywords: Document Similarity, Nepali Text Classification, Morphological analysis, Vector Space Model, Bag-of-words Model, N-gram, Bi-gram, Nepali News Classification

I. Introduction

The availability of news in electronic form is ever increasing mainly because of the rapid growth of the World Wide Web. The task of automatic classification of such colossal news is emerging as the key challenge for organizing that huge information and also for any processing with an aim of knowledge discovery in this information. Proper classification of online news needs text level analysis using various natural language processing and machine learning techniques to get meaningful knowledge. Text classification is becoming interesting to many researchers, which consists of several challenges like appropriate document representation, dimensionality reduction to handle algorithmic issues and an appropriate classifier function to obtain good generalization. The language level specifics, which might be entirely different from one language to another language both at syntax and semantics adds other challenging issues on text classification problem.

Vector Space Model (VSM) represents each document as a feature vector of the terms in the document. Each feature vector contains term weights of the terms in the document. First step in classification system based on Vector Space Model (VSM) is the generation of words. Words are generated using analyzer. Different analyzers available for English text cannot be used for Nepali text due to the differences in the language. Preprocessing is done by analyzer before generating final set of words for VSM.

An analyzer tokenizes text by performing number of operations on it, which include extracting words, discarding punctuation, removing accents from characters (for certain languages), lowercasing, removing common-words which is also termed as stopwords, reducing words to a root form, etc. These operations are language dependent and exact implementations vary from language to language.

For an example, in English, words such as the, an, a, etc., are very common and are used as stopwords. In Nepali text, these stopwords do not exist and new stopwords are needed to be identified. It is also common to process verbs to reduce them to their roots for English text. In Nepali language, root verbs are combined in different ways to form new verbs. Similarly, different suffixes are added to nouns and pronouns to form different words. There are various forms of word reduction based on suffixes as per the nouns and pronouns used in a particular sentence and context. Such feature is not seen in English text. Lowercasing is common in English but is not applicable in Nepali text. Similarly, accent is used in Nepali text. Another feature common in Nepali language is different forms of words with same meaning. These words are not the synonym words, rather similar words but written in different forms with minor variations on characters being used in writing. Examples are अवरोद्ध - अवरोद्ध, उपलब्धि - उपलब्धि, कमिटि - कमिटी, इकाई - इकाई, आइतवार - आइतवार, अवकाश - अवकाश, etc. It is required to substitute such different forms with single form. N-gram is a continuous sequence of n-words from the given text. While N-gram can be used in character level, this paper uses N-gram in word level. A sentence म भात खान्छु, results in म-भात and भात-खान्छु using N-gram when $N = 2$. Although experiments were done using $N > 2$ also, the paper shows results with $N = 2$. N-gram with $N = 2$ is often referred to as bi-gram model.

In addition to these all syntax level processing, this paper also investigates the effects of combining semantics based processing methods and preprocessing based on Nepali language features. Although the principle focus of this research work is in news classification, this research contribution is equally applicable in building news clustering models for news search engine optimization similar as Zhang and Dimitroff models [13] and Kresteland Mehta [8] for the purpose of designing efficient news recommendation systems.

The rest of this paper is organized as follows. Section II discusses previous works related to this paper. Section III introduces baseline approach and some other methods. It then discusses the proposed approach using preprocessing based on Nepali language features. Section IV then discusses the experimental setup for the methods. Based on the experiments, section V shows the evaluation of these methods and discusses the performances of the classifier. Finally, section V summarizes and concludes the paper.

II. Related Works

VSM represents each document as a feature vector of the terms including both words and phrases [12]. Each feature vector contains term weights of the terms in the document. In the simplest form, it does not consider the dependency between the terms and ignores the sequence and structure of the term in the document. A document is represented by n-dimensional term vectors in VSM. A term vector is a collection of term-weight pairs. The weight of a term depends on the frequency of occurrence of the term called Term Frequency (TF). Term Frequency - Inverse Document Frequency (TF-IDF) weight outperforms TF and is commonly used weights [5,6]. A wide variety of distance functions and similarity measures have been used, such as squared Euclidean distance, cosine similarity, and relative entropy. Cosine similarity is a commonly used similarity measure [3,4].

Khan et al. proposed the semantics based feature vector using Parts-of-Speech (POS) model for text classification [5]. The feature space was reduced remarkably considering POS. Masuyama and Nakagawa presented the roles of the different POS in feature selection and showed that nouns best describe a category's contents [10]. Krestel and Mehta used Latent Dirichlet Allocation (LDA) to find the hidden

factors of important news stories [8]. Authors focused on verb, adjective and noun for part-of-speech (POS) information. For Named-Entity information, the most common named-entities like person, locations, organization and job-titles were used for efficient results. Lo, He and Ounis generated stopwords automatically using frequency of occurrence of words for information retrieval system [9]. Basnet and Pandey have shown different aspects of morphological analysis of verbs in Nepali [1]. The study focused on inflection aspect of verb morphology and the use of compounding of verbs for Nepali language.

Latent Semantic Indexing (LSI) remained one of the predominantly used techniques in information retrieval systems because of the method featuring in dimensionality reduction and overall quality improvement in results [2,3]. LSI uses Singular Value Decomposition (SVD) to find low rank approximation of the original term space. Users in different contexts, or with different needs, knowledge, or linguistic habits will describe the same information using different terms. In contrary, same word may have more than one distinct meaning. LSI captures the essential meaningful semantic associations while reducing redundant and noisy semantic information [2]. Paulsen and Ramampiaro combined LSI with a new clustering algorithm to retrieve and cluster biomedical information using Lucene and JAMA API in Java [11]. They obtained best result when rank was reduced to few hundreds. Gleich and Zhukov used SVD to recommend related terms at varying levels of generality by varying the rank of SVD space [3]. Kafle et. al. compares classification of Nepali documents using cosine similarity and SVM along with word2vec and TF-IDF [14].

III. Methodology

The proposed method uses various Nepali languages features to reduce the dimension of feature space. These feature based improvements are cascaded in similar style as Masuyama and Nakagawa [10] nevertheless the authors used different method than the proposed method. Finally the results are verified using cross-fold validation techniques detailed out as in [7].

A. Algorithm of Baseline Method

- Split the whole documents into training and testing datasets. The splitting ratio will be different in each iterations of validation cycle following k-fold cross-validation.
- Analyze the news document using StandardAnalyzer in Lucene¹.
- Calculate the term weight using the standard TF-IDF calculation scheme.
- Using the training documents, compute the term-weight vectors, which is also known as document vectors.
- Use term-weight vectors associated with training documents of each class to compute corresponding centroid vector.
- Compute term-weight vector of test documents, exactly repeating similar steps of training documents.
- Compute similarity measure between the test document and news classes. Similarity measure between a document and a class is calculated by computing the cosine similarity between the test vector of the former and centroid vector of the latter.
- Classify the test document to a class which gives minimum similarity measure.
- Repeat whole processes to evaluate using k-fold cross-validation.

B. Algorithm of Proposed Method

- Generate stopwords using frequency thresholding where frequency is the total number of documents in which a term appears. Remove stopwords from the complete set consisting total terms.
- Replace व with व, इ with ई, ु with ू, ि with ि, ढ with ध, ड with द, ठ with थ, ट with त and श with स.
- Remove word suffices such as बाट, द्वारा, मार्फत, देखि, सँग, तर्फ and सम्म.
- Generate terms using n-grams from each document.

¹ Lucene 3.6.1 and JDK 1.7.0 were used for processing and baseline evaluation purpose. Lucene can be downloaded from <http://lucene.apache.org/>

- Calculate weights of the reduced term space.
- Calculate term-document matrix from the reduced term space.
- Generate term-weight vector from the new term-document matrix.
- Evaluate the classifier using k-fold cross-validation.

IV. Experiment and Evaluation

The data required for this work was prepared from the raw dataset used for morphological analysis of Nepali text by Basnet and Pandey [1]. The original dataset consists of 71981 news documents, occupying 453 MB disk space, collected from various sources of Nepali daily newspapers such as Gorkhapatra, Kantipur, Samacharpatra, Mahanagar, Nagariknews and Annapurna Post published during January 2009 to November 2009. The dataset was used for morphological analysis of Nepali text by Basnet and Pandey [1]. Data cleaning was required before the dataset could be used. Duplicate news documents were replaced with unique news documents. The dataset containing non-Nepali encodings were also removed. Many news documents contained more than one news items in the same document, which was useless for classification, as each news document must belong to a single category.

To test the performance of the classifier, actual category of news document must be compared with the category predicted by the classifier. A web-based application was developed for this purpose. A web-interface displays news from the dataset and human user can select respective category. After selection, the provided category was stored in a database. The web-interface was developed using HTML, PHP and mysql. The database consists of two tables: “ncategory” and “news”. The table “ncategory” stores the news categories which are loaded as options for classification. A user is provided the content of the news to be categorized and available options. The information submitted by the user is stored in the table “news”. The information includes the news, category selected and user’s name. Fig. 1 shows the screenshot of the web-interface developed for manual categorization of news documents.

After going through such rigorous process of cleaning and manual categorization, dataset of 700 news documents is prepared. Initially, 50% were used for training and 50% were used for testing. Later the document set splitting was done following k-fold cross-validation. Different categories chosen for the model experimentation are shown in Table I.

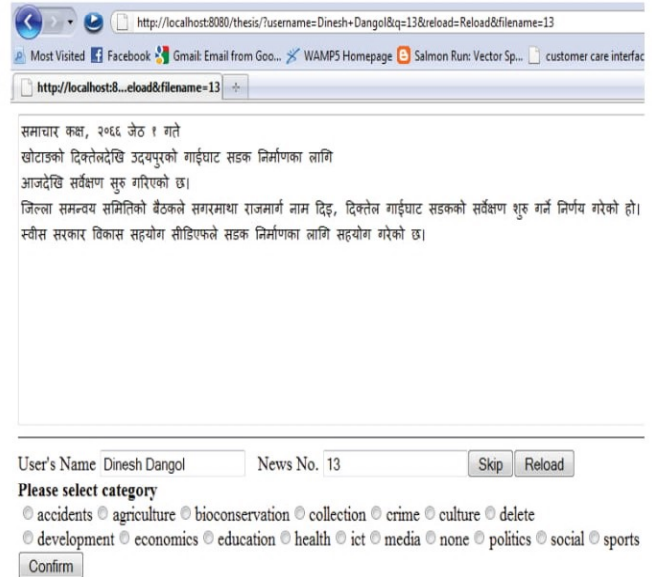


Fig. 1 Screenshot of web interface used for manual classification

TABLE I
Categories of the News Documents

No.	Category	No. of documents
1	Accidents (A)	100
2	Politics (P)	100
3	Sports (S)	100
4	Development (D)	100
5	Health (H)	100
6	Education (E)	100
7	Crime (C)	100
	Total	700

Confusion matrix was created from the result of classification. Precision, recall and accuracy were used for evaluation of the classifier. Precision of a class measures the ratio of correctly classified documents to the total documents classified in the class. Recall of a class measures the ratio of correctly classified documents to the total documents in a class. Table II shows the confusion matrix of one of the experiments using baseline method. Table III shows the calculation

of precision, recall and accuracy using True Positives (TP), False Negatives (FN), False Positives (FP) and True Negatives (TN) derived from confusion matrix of Table II.

TABLE II
Confusion Matrix of an Experiment on
Baseline Method

P		Predicted class						
		A	D	C	S	H	E	
Actual class	P	93	2	2	0	0	2	1
	A	0	83	5	4	0	0	8
	D	0	1	70	16	8	1	4
	C	0	0	13	70	4	1	12
	S	0	0	9	10	71	6	4
	H	0	0	8	2	3	83	4
	E	0	2	6	22	3	0	67

TABLE III
Performance Measures of an Experiment on
Baseline Method

Class	TP	FN	FP	TN	Pr	Re	Acc
P	93	7	0	600	1	0.93	0.99
A	83	17	5	595	0.94	0.83	0.96
D	70	30	43	557	0.61	0.7	0.89
C	70	30	54	546	0.56	0.7	0.88
S	71	29	18	582	0.79	0.71	0.93
H	83	17	10	590	0.89	0.83	0.96
E	67	33	33	567	0.67	0.67	0.90
Avg.	76.71	23.28	23.28	576.71	0.78	0.76	0.93

Average precision for 7 classes were calculated for each experiment using 2-fold cross-validation. Experiments were repeated 20 times and average values were recorded. Baseline method uses standard analyzer to generate terms. First step was to filter commonly occurring words. Stopwords were generated using frequency thresholding. Top two most frequent terms 5 and / were selected as stopwords. Second step was to replace various word forms. Different forms of replacements and corresponding number of terms reduced are shown in Table IV. After this, suffices that occur in nouns and pronouns were removed to reduce the dimension further. Suffices that gave best results are बाट, द्वारा, मार्फत, देखि, सँग, तर्फ and सम्म.

Table V shows the effect of addition of new methods applied to the baseline method on performance measures. These three methods remarkably reduced the dimension of the feature to be used for classification and also increased average precision and recall compared to the baseline method as shown in Fig. 2.

TABLE IV
Effect of Word Replacements on
Dimension Reduction

Word replacement forms	No. of terms reduced
बव	233
इई	51
उऊ	228
णि	134
ढध	3
डद	7
ठथ	4
टत	11
शस	82
All combined	746

Fig. 3 shows the comparison of average accuracy percentage among different methods.

TABLE V
Effect of Preprocessing on Classifier
Performance

Code	Methods	Average precision	Average recall	Average accuracy	No. of terms
B	Baseline	0.7863	0.7699	93.42	28903
BS	Baseline with stopword filtering	0.7878	0.7773	93.63	28901
BSR	Baseline with stopword filtering and word replacement	0.7905	0.7800	93.71	28157
BSRS	Baseline with stopwords filtering, word replacement and suffices removal	0.7902	0.7803	93.72	27292
BSRNN	Baseline with stopwords filtering, word replacement, suffices removal and bi-gram	0.8176	0.8005	95.81	27292

V. Conclusion and Future Works

The language features are always important to be considered in text analytics. This paper presented the Nepali language specific features which are different than English language features. The results with feature based processing are quite promising in comparison to baseline methods. Both stopword filtering and word replacement are key processing to be included for the increment in precision and recall. The reduction in number of terms was also observed. Morphological analyzer that removed specific suffixes increased both the average precision and average recall compared to the baseline method. The results were further improved by using n-gram based word selection.

Only suffixes that occur in nouns and pronouns were only considered in this paper. Stemming algorithms in Nepali may be used to reduce different forms of verbs. Only common forms of word replacements were considered in this paper. Other forms of replacements are still possible. Examples of replaceable word pairs are ओखलढुंगा - ओखलढुङ्गा, एवं - एवम्, काठमाडौं - काठमाडौ, इन्स्टिच्युट - इन्स्टिच्युत, etc. More replacements may improve dimension reduction and classifier performance further.

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