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Sukkur IBA University has been imparting education with its core values merit, quality, and excellence since its inception. Sukkur IBA University has achieved numerous milestones in a very short span of time that hardly any other institution has achieved in the history of Pakistan. The university is continuously being ranked as one of the best university in Pakistan by Higher Education Commission (HEC). The distinct service of Sukkur IBA University is to serve the rural areas of Sindh and also underprivileged areas of other provinces of Pakistan. Sukkur IBA University is committed to serve targeted youth of Pakistan who is suffering from poverty and deprived of equal opportunity to seek quality education. Sukkur IBA University is successfully undertaking its mission and objectives that lead Pakistan towards socio-economic prosperity.

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Prof. Nisar Ahmed Siddiqui
(Sitara-e-Imtiaz)
Vice Chancellor, Sukkur IBA University
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Editorial

Dear Readers,

It is pleasure to present to you the fourth issue of (issue 2, volume 2) of Sukkur IBA Journal of Computing and Mathematical Sciences (SJCMS).

The technological innovations and advancements enabled the easiness of life. From the smart wheelchairs to smart homes, automated cars and smart agriculture, we are equipped with information and communication technology. To design smart devices, variety of sensors are used that generate massive data that creates a huge opportunity for the researchers. In order to cope with the future technology challenges, the SJCMS aims to publish cutting-edge research in the field of computing and mathematical sciences for dissemination to the largest stakeholders. SJCMS has achieved milestones in very short span of time and is indexed in renowned databases such as DOAJ, Google Scholar, DRJI, BASE, ROAD, CrossRef and many others.

This issue contains the double-blind peer-reviewed articles that address the key research problems in the specified domain The SJCMS adopts all standards that are a prerequisite for publishing high-quality research work. The Editorial Board and the Reviewers Board of the Journal is comprised of renowned researchers from technologically advanced countries. The Journal has adopted the Open Access Policy without charging any publication fees that will certainly increase the readership by providing free access to a wider audience.

On behalf of the SJCMS, I welcome the submissions for upcoming issue (Volume-3, Issue-1, January-June 2019) and looking forward to receiving your valuable feedback.

Sincerely,

Ahmad Waqas, PhD
Chief Editor

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Tuberculosis: Image Segmentation Approach Using OpenCV

Abdullah Ayub Khan* Anil Kumar† Gauhar Ali†

Abstract

Tuberculosis (TB) is one of the major disease spreading all over the world. TB caused by bacteria is known as Mycobacterium tuberculosis. Nowadays, TB is increasing widely in the region of Karachi and now it's becoming a challenging task for all researchers. The process is to partition the digital image into different segments according to the set of pixels known as image segmentation. It's used to find segments & extract meaningful information of an image. Image segmentation approaches are providing new ways in the field of medical and it's exactly suitable for TB images, block-based & layer-based segmentation helps to identify edges, thresholding, regional growth, clustering, water shading, erosion & dilation, utilizing histogram for the betterment of TB patients. Chest X-ray is playing a vital role to diagnose TB rapidly. TB image contains binary colors, it's either black & white but it would have been a different level of the color shades. Diagnosing symptoms and intensity of TB in a patients' x-ray is such a critical problem. The purposed solution is to overcome the problem and reduce the ratio of TB patients in Karachi region by using image segmentation approaches on chest X-ray and calculates the alternative way to detect the intensity level of TB in individual patient's report with effectively, efficiently & accurately with a minimum amount of time by using Python OpenCV.

Keywords: *Image Segmentation Approaches, Tuberculosis (TB), Medical Imaging, Binary Color, Python, OpenCV*

1. Introduction

Tuberculosis (TB) is becoming a hardly manageable disease in recent era throughout the world, the rate increasingly goes up in the region of Karachi. TB caused by a bacterium named Mycobacterium Tuberculosis (MTB). It mostly effects on lungs but sometimes it infects on other organs in the human body. It can spread from one person to another through the air. The first TB infection happened about 9,000 years ago [1]. According to researches, it's the second biggest killer disease in the world. In 2015, 1.8 million people died and 10.4 million people fell ill by tuberculosis [2]. The ratio is going to increases day-to-day. In the list of world populations, Karachi is in 3rd position[1] [3]. Last few years, TB expand rapidly in the region of Karachi. According to "National TB Control Program", every year TB kills 90000 people in Pakistan. In Karachi 2010-2013, more than 14000 TB patients were registered [4]. In 2016, Sindh 4th Quarter Tuberculosis (FTI) survey shows 15290 patients infected by all types of TB and 6798 patients are newly registered [5], that's meant more than 22000 patients are affected by TB in Sindh. In short, tuberculosis killed more "Karachiites" than terrorist did.

A single picture translates more information about the scene than a human can. Image segmentation (IS), the process in which an image is converted into multiple portions. These portions are used to find objects, features or related information of a digital image. The objective of IS is to analyze coherent objects, pixels, color, shapes, corner, edges, etc. for the meaningful understanding of an image. IS is also used to label each pixel and these labeled pixels has some specific characteristics. There are some certain techniques of an Image Segmentation which are: thresholding, region-based segmentation, regional growth, edge detection, filtering, hybrid segmentation (water shading). Such techniques are used in chest x-ray of Karachi's patients to identify TB segmentation using Python OpenCV.

The proposed solution tries to minimize time computation as-well-as reduce cost and increase productive

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[1]http://www.citymayors.com/statistics/largest-cities-population-125.html

treatment of TB patients using x-ray-based image segmentation. By the help of this, TB can easily be diagnosed, treatment can easily be started without waiting for other report. Chest x-ray image segmentation techniques can be applied for finding the intensity (color, shape, texture based, etc. using thresholding and edge detection etc.) of TB. In this paper, the proposed solution will answer these queries: which part of the lungs is affected? what category of TB patient has? it affects lungs first time or not? how to prevent? how it will take time to overcome this problem? how to apply IS techniques? how computer vision helps to find the solution in medical imaging? and many more. The motive is just scan patient chest (x-ray), diagnose the symptoms of TB, ensure the category of TB, need to know the way of treatment, start treating without wasting of time. It's like a report less treatment.

2. Related Work

Segmentation of organs accurately using chest x-ray is a well-defined problem in the field of medical imaging, find coherent objects of an image and extract useful knowledge in it which help to move one step ahead in medical field. Several papers published related to IS and TB (chest x-ray) in past few years. Some latest literature reviewed in this section, crucial key factors are discussed below:

Nida M. Zaitoun et.al briefly elaborates the importance of image segmentation (IS) in image processing (IP). IS is not just finding edges (coherent object) of an image, but there is a lot of other feature which help identify complete sense of an image. Methods for IS splits into two parts block-based segmentation & layer-based segmentation. In block-based segmentation, divide into two main categories region based & edge based. Region based methods contains Region Growth, Split & Merge, Clustering, Thresholding and Normalized cut. Same as, edge-based methods contain Roberts, Sobel, Prewitt, Canny. Soft computing approaches has famous algorithms like Neural Networks, Genetic Algorithm, Fuzzy logic [6]. N. Dhanachandra et.al highlights some crucial factors of IS IS is the first step of IP. Article explains the importance of clustering algorithms in IS. IS contains lots of techniques but clustering provides advance features in the field of IP. Although it is derived by block-based segmentation, the objective of clustering is to classify clusters of different objects. To categorize clusters, we need algorithms like k-mean, fuzzy c-mean, subtractive, expectation and maximization, DBSCAN. Each algorithm has different ability to group data (cluster) of an object in an image [7]. Pixel is a prime factor in medical imaging. Group of pixels of different objects can be used to observe similar data and easily locate the point of interest of an image where we can easily analyze.

Frieze, Julia B et.al defines the ratio of childhood TB in Cambodia. The childhood TB cases are increasing rapidly with $10\% - 20\%$ of total TB cases. In between 2015-2016, diagnoses half a million new cases emerged and almost 74000 people died annually because of TB. In adults, it can easily diagnose TB for analyzing chest x-ray reports but in children, most of the time it can't be detected because it's difficult to diagnose as-well-as hospital needs latest equipment & technology in Cambodian hospitals. Diagnoses of TB in children is such a challenging task. It exceeds 87% in the last year. The proposed solution, Cambodian's provinces are divided into Operational Districts which cover 1,80,000 people. These Operational Districts report to National TB Program in Cambodia. Overcome of childhood TB diagnosis, take an interview of each child parents or guardian who have been suffering from TB since childhood. After gathering data, deliver knowledge to hospitals and provides training [8]. TB isn't the problem of Pakistan & Cambodia, but it spread all over the world. World should take some necessary action to eliminate this killer disease assoonas possible. Rangaka, Molebogeng X et al suggested the idea related to reduction of tuberculosis infection in the globe.The roadmap provided by researchers with implementation barriers and challenges. The solution based on the clinical and technical approach, health-systems, policy & leadership, advocacy approach [9].

Color image segmentation of tuberculosis bacilli in ziehl-neelsen-stained tissue image using clustering approach. In clustering, moving k-mean algorithm can segments group of TB infection manipulate into color-based. The original image which is based on RGB can be converted into C-Y transformation, applying k-mean algorithm with median filters for removing noise, after that regional growing can separate image into multiple regions, finally image can be segmented properly for the detection of TB bacilli [11]. Raof, M. Y. Mashor, and S. S. M. Noor segmented TB bacilli in ziehl-neelsen sputum slide images using clustering algorithm. Separating foreground & background of medical image with accuracy plus efficiency. Modification of medical imaging, segmentation is performing a vital role [12]. The idea of automated image segmentation proposed by Riza et.al. The step-by-step method interprets the overall scenario of automated image segmentation of TB bacilli. It starts with image contrast which enhances image in order to clear and brighten, after contrasted color space can be done for detecting infections, change RGB color into image label and image clustering pixels image into multiple color objects, at last it can be segmented exactly [14]. Image processing is also effective for diagnosing TB bacilli. This research is done on MATLAB software tool for detecting and counting TB bacilli using color-based approach segmentation with accuracy [13]. Machine learning and knowledge-based system also contributes in the medical imaging (MI) field. Melendez, Jaime et al describe the computer aided detection using supervised learning & deep learning for MIS [10].

The above literatures having reviewed, we come to the point that majorly IS working can be done with machine learning or clustering algorithm, to group similar data or infection. Most of the time it can be done on MATLAB or other well-known popular tools (as already mentioned above). So, we are utilizing the efficiency of Python interact with OpenCV for extracting the highest percentage rate of accuracy of TB images with minimal amount of time.

3. Proposed Methodology

The proposed solution elaborates unique identification of TB in short period of time using OpenCV 3.4, Matplotlib & NumPy collaborate with Python 3.6.5. We explain the importance of image segmentation in the field of medical.

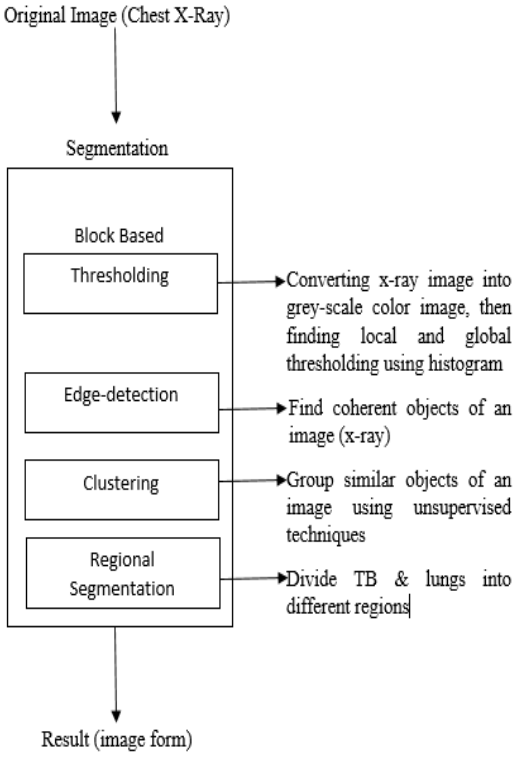

Figure 1: Graphical Representation of The Proposed Solution

In this research article, mentioned above the graphical representation of proposed solution can appropriate for diagnosing TB intensity with minimal amount of time. In the first step (pre-processing), applying filtration of an image for removing noise and enhancing image quality in terms of smoothing, sharpening, and restoring. In the next step, we perform several activities of block-based segmentation, convert image into grayscale histogram and applying thresholding to find the impact of TB on lungs. After, separation the coherent object on lungs by using edge detection. Cluster means group similar objects, k-mean algorithm utilizes for finding k-neighboring. At the end, an image can be separated into two regions, one is infected by TB and the other is the lungs. Below the result section shows the overall mechanism of segmentation approaches with detailed description and graphical view.

4. Tools & Packages

In this context, considering crucial parts of the research is to pick suitable tool, packages and programming language. These things play a vital role in our research for analyzing image data & retrieving meaningful information. The next two sections define the importance of tools for managing and maintaining tuberculosis patients' data and transform it into useful manner.

4.1 Python

Python is one of the powerful tools for making program, projects and portfolio. Program in terms of creating different projects for performing specific task and it can reduce load of the machine. Python is a programming paradigm which supports lots of programming abilities like object-oriented, structural, high-level, functional, interpretation and dynamic scripting skills[2] . There are two main versions named: latest version (it starts with 3.0 or so on) and popular version (2.7 or so on). In this research, we follow the latest version which is python 3.6.5, it gives complete programming facilities including built-in functions like: list-comprehension, slicing, dictionary, corpus, lambda, set, sort, min/max, reverse, user define function (UDF), etc. which reduce the programming complexity; by this act it increases efficiency. Python provides functions which decreases line of codes and increases accuracy. In python, lots of external open source libraries available on internet some most important: nltk (nltk corpus, tokenization, stemming), Pycrypto, OpenCV, Matplotlib, NumPy & many more. There is no need to learn each and everything, each library is expressive in nature meant that all is similar with each other. Just extract it and use it as per need. Providing functionality and simplicity of context, user can easily understand as use it without any difficulty. In this nature, we utilize this powerful language in our research with interact other library for segmentation.

4.2 OpenCV

In this article, our main focus is on OpenCV just because of image segmentation. OpenCV is an open source library which is used in computer vision field conjointly with python to make a useful program for specific task. More than 2500 optimization algorithms including comprehensive of both state of the art and

[2]https://www.python.org/doc/essays/blurb/

classic computer vision as-well-as machine learning algorithm. Utilization of all these algorithms we get line detection, edge detection, corner, moving objects, motion sequence, feature detection and recognition, segmentation, image stitching, field of view (panorama), human motion detection, human gesture & posture detection of suspicious person, face detection, finger-print detection and much more. Number of downloads exceeded more than 14 million till now. Is has an ability to collaborate with C++, java, python, MATLAB and it provides interface for all operating systems like Mac OS, Linux, Window, Android. There is an extensive use of OpenCV through all over the Globe. Many big companies utilizing OpenCV for completing so many CV (Computer vision) tasks. OpenCV is written in C++, it's easy to use and provides lots of functionalities for design and implementation of CV products.

5. Dataset

Karachi X-Ray[3] shared with us the crucial data of Karachiites' TB patients. The data is based on images form (chest x-ray) which were collected at the beginning quarter of the year 2018 (shown in figure 2). In this article, there are thirty-four different images of different patients including men, women & children. These people live in Karachi. New patients are also recorded in the year 2018. Many lives survive against world's challenging problem for many years. But it never is decreased since recent year, although it spread one to another person rapidly. In fact, the contagion is also in a newly born baby as well. Apply image segmentation on it and overcome with a different solution in computer vision field.

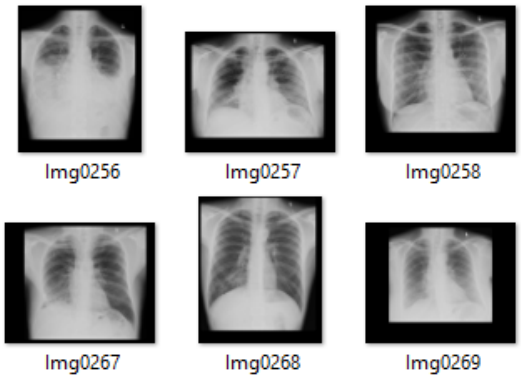

Figure 2: TB Original Images

6. Result & Discussion

In result section, we are describing the overall mechanism using in this research, detection of tuberculosis in lungs x-ray images. There are important steps which analyze image, extract information, retrieve & store. Block-based image segmentation approaches segments coherent image in various manner like thresholding, edge detection, filtration (low pass & high pass), regional growth, and clustering. The steps are mentioned below with some description & graphical representation.

Filtration:

The first step is preprocessing, removing noise. Filtering is the process which enhances the image features. There are two main types of filtering, low-pass and high-pass filter. In this research, kernel convolution 3x3 n-d matrix is used to smoothing, edge enhancement and sharpening of the images (shows in figure 3).

```
[[-1. -1. -1.]
 [-1.  8. -1.]
 [-1. -1. -1.]]
<class 'numpy.ndarray'>
```

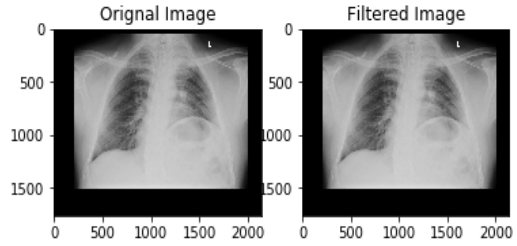

Figure 3: Removing Noise Using 3x3 Kernel n-d matrix

Thresholding:

It converts grayscale image into binary color (0 & 1) and find intensity of black & white portion of the image, lungs can be detecting as black color and white shows how much TB affected on lungs (shows in figure 4). There are several thresholding approaches available, the research adopts five different forms of thresholding, which are: 'Binary', 'Binary Inverted', 'Zero', 'Zero Inverted' & 'Trunc' (shows in figure 5. In this research, we set thresholding value between 127 to 255, for clear understanding of binary image intensity (see some graphical representation in histogram).

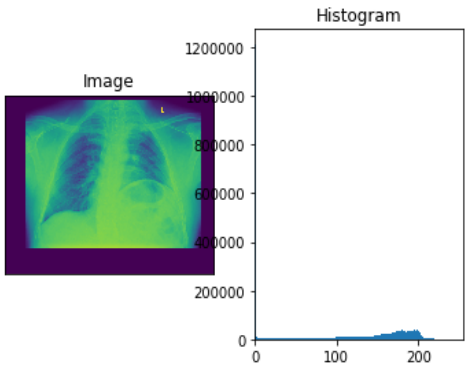

Figure 4: Thresholding

[3]The number one health diagnostic center (link: http://karachixrays.com)

It's an image processing technique used to detect boundaries of objects in an image. In edge detection, various types of algorithms already developed, canny edge detection is appropriate for medical imaging. Gaussian kernel 5x5 n-d matrix, intensity gradian 'L1' and 'L2' norm, L1 level of intensity sets between 20 to 40, and L2 between 20-30 ratios (shows in figure 6).

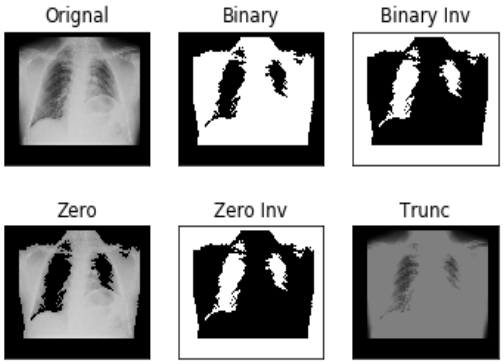

Figure 5: Types of Different Thresholding Applied

Figure 6: Canny Edge Detection

Clustering:

In clustering, segmentation can be done on group of similar objects (cluster) in an image. Unsupervised, no labelling, K-mean clustering algorithm used to assemble similar objects. In the research, we set kth value as k=2, 4, and 6.

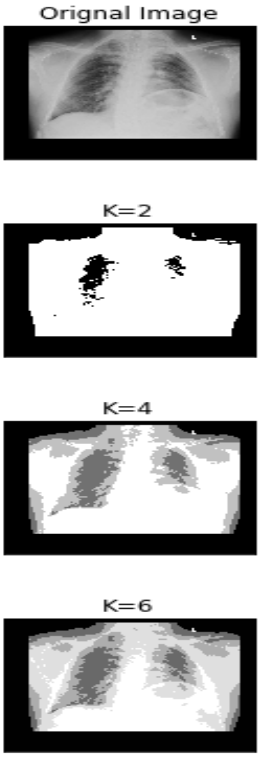

Figure 7: Clustering (K-mean with different K points)

Regional-Based Segmentation:

Separate an image background and foreground into different regions. Furthermore, segmentation of an image objects, color, shapes, texture, and more features are becoming different regions (figure 8 & 9). Choosing the interested region for segmenting and extracting hidden pattern or meaningful knowledge in that image.

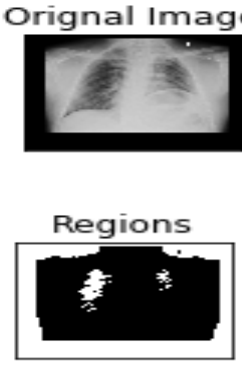

Figure 8: Clustering (Separating Regions of an Image)

Figure 9: Clustering (Erosion & Dilation of an Image)

7. Conclusion

Medical imaging is the hot topic nowadays, detecting diseases in a human body is a critical task for all researchers. Tuberculosis (TB) is the emerging problem in the Karachi region, resolving such type of situation we need some tools and techniques. Computer vision provides a different path for recognizing objects in an image, and machine learning algorithms help identify efficiently. Image segmentation approaches recognize image into different segments such as color, texture, shapes, size, edge, objects, and regions. Categories segmentation into three main parts but block-based segmentation is suitable for detecting TB in x-ray. In block-based, segmentation can be done by filtering, thresholding, edge detection, clustering & regional growth. In this research, we applied all those techniques and elaborate on the importance of each. OpenCV, NumPy and Matplotlib try to summaries code of thresholding, Canny edge detection, clustering, and regional growth in python 3.6.5, given image as an input and display image as an output but get hidden patterns or meaningful information. The result section clearly shows, block-based image segmentation is one of the best solutions for medical imaging, it separates accurately background and foreground of an image (chest x-ray), which help to detect the intensity of TB on lungs with a minimal amount of time. Our main objective, to ensure a better understanding of IS approaches in the medical field which help diagnose diseases, take suitable action in terms of treatment and reduce the rate of patients recodes in health sector department.

8. Future Work

Tuberculosis is widely expanding not only in Karachi but overall in Pakistan. Millions of people affected and new cases emerging in regular bases. For successfully done image segmentation approaches in the region of Karachi. Now, our next target to apply the same scenario in whole TB patients of Pakistan.

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Stabilization of Vertically Modulated Pendulum with Parametric Periodic Forces

Babar Ahmad* Sidra Khan*

Abstract

With the application of Kapitza method of averaging for arbitrary periodic force, a vertically modulated pendulum, with periodic linear forces is stabilized by minimizing its potential energy function. These periodic linear forces are selected in range [-1, 1], further the corresponding stability conditions are compared with that in case of harmonic modulation. Later, a parametric control is defined on some periodic piecewise linear forces, and the nontrivial position is stabilized under different conditions by just adjusting the parameter.

Keywords: *Kapitza pendulum, fast oscillation, parametric control*

1. Introduction

A simple pendulum that is suspended under the influence uniform gravitational field has versatile applications in Nonlinear Physics. The Mathematical Relationships and the differential equations associated with pendulum plays an important role in the theory of solutions, in the problem of super radiation, in quantum optics and the theory of Josephson effects in weak superconductivity [1]. A simple pendulum has only one stable point i.e. vertically downward position, while a vertically modulated pendulum with very high frequency, has upward position also stable. This concept was initialized by Stephenson in 1908.[2, 3, 4]. In 1951, Pjotr Kapitza explained experimentally such kind of extraordinary behavior of pendulum in detail, and corresponding experimental instrument is known as Kapitza Pendulum [5]. In 1960 Landau et al. examined the stability of this system driven by harmonic Force [6]. Later on, Ahmad and Borisenok replaced harmonics force with periodic kicking forces and modified Kapitza Method for arbitrary periodic forces [7]. Ahmad also examined the stability of the system excited by the symmetric forces with comparatively low frequency of fast Oscillations [8]. Later on, the behavior and the stability of a parametrically excited pendulum have been examined [9, 10]. In 2013, Ahmad used parametric periodic linear forces for the horizontal modulated pendulum and discussed its stability by minimizing the potential energy function [11]. In this paper, the stability criterion for vertically modulated pendulum, driven by periodic piecewise linear forces will be discussed.

2. Kapitza Method For Periodic Arbitrary Forces with Zero Mean

Consider one dimensional motion of a particle of mass m in conservative system. If U is potential energy function, then its equation of motion is

$$F(x) = \frac{-dU}{dx} \tag{1}$$

In this case the system has only one stable point. If a periodic fast oscillating force with zero mean is introduced, The system may have more than one stable point. This fast oscillation means that if $\omega_0 = \frac{2\pi}{T_0}$ is the frequency due to F_1 and $\omega = \frac{2\pi}{T}$ is the frequency due F_2 then $\omega >> \omega_0$. This fast oscillatory force has the Fourier expansion as

$$F_2(x,t) = \sum_{k=0}^{\infty}[a_k(x)cos(kwt) + b_k(x)\sin(kwt)] \tag{2}$$

Here a_k and b_k are the Fourier coefficients. In Calculus, mean value of a function $f(t)$ is denoted by bar, if T is the time period, then mean is defined as

$$\bar{f} = \frac{1}{T}\int_0^T f(x,t)dt \tag{3}$$

The Fourier coefficient a_0 is defined as

$$a_0 = \frac{2}{T}\int_0^T f_2(x,t)dt \tag{4}$$

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From equation 3 and 4, the mean value of a function is equivalent to Fourier coefficient a_0

$$\bar{f} \cong a_0(x) \tag{5}$$

The other Fourier coefficients are

$$\begin{aligned} a_k &= \frac{2}{T}\int_0^T f_2(x,t)cos(kwt)dt \\ b_k &= \frac{2}{T}\int_0^T f_2(x,t)\sin(kwt)dt \end{aligned} \tag{6}$$

Ignoring friction, we can say that only two forces are acting on the system, hence its equation of motion is

$$m\ddot{x} = F_1(x) + F_2(x,t) \tag{7}$$

Due to these forces, two types of motion namely smooth and small oscillations are observed. So we represent the path of oscillations as the sum of smooth path $X(t)$ and small oscillation $\xi(t)$

$$x(t) = X(t) = \xi(t)$$

By averaging procedure, the effective potential energy function can be expressed as

$$U_{eff} = U + \frac{1}{4mw^2}\sum_{k=1}^{\infty}\frac{a_k^2 + b_k^2}{k^2} \tag{8}$$

For stability of the system, we have to minimize effective potential energy function given by 8

3. The Pendulum Driven by Harmonic Force

Consider a pendulum whose pivot point is forced to vibrate vertically (see Figure 1), under the influence of the harmonic force. The harmonic force is given as

$$f(t) = \sin(wt) \ if \ 0 \le t \le T \tag{9}$$

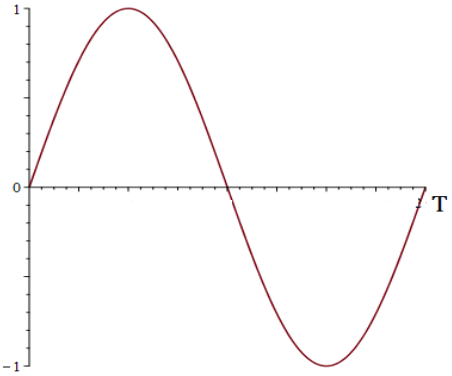

Figure 1: Kaptiza Pendulum with Vertical Oscillation

and shown in Figure 2

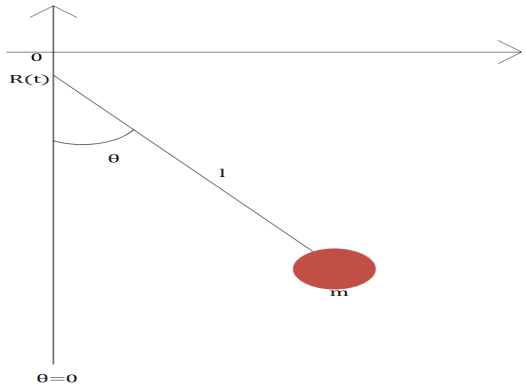

Figure 2: sin type force

And the force acting on the pendulum is

$$f_2(\phi,t) = mw^2\sin\phi \times f(t) \tag{10}$$

Its Fourier coefficient is $a_0 = 0$ indicates that its mean value is zero. By using 6, the other Fourier coefficients are:

$$\begin{aligned} a_k &= 0 \\ b_k &= mw^2\sin\phi \end{aligned} \tag{11}$$

so the effective potential energy is obtained by using 8

$$U_{eff} = mgl(-cos\phi + \frac{w^2}{4gl}\sin^2\phi) \tag{12}$$

The following results are obtained after minimizing equation 12

- The downward position $\phi = 0$, is always stable.
- Vertically upward position $\phi = \pi$ is stable if $w^2 > 2gl$.
- The position $\phi = arccos(-\frac{2gl}{w^2})$ is unstable.

4. Vertically Modulated Pendulum Driven by Periodic Linear Forces

Now, replacing the harmonic force with some periodic piece-wise linear forces within the range of harmonic forces, Our aim is to stabilize the pendulum at $\phi = \pi$ with low frequency as compared to harmonic force. These periodic linear forces are T-periodical: $S(t+T) \equiv S(t)$. These forces are considered as following.

$$f_2(\phi,t) = mw^2\sin\phi \times S(t) \tag{13}$$

Inclined Type Force: First of all consider an inclined type force: $E(t) = E(t+T)$, given by equation 14 and illustrated in Figure 3

$$E(t) = -\frac{2}{T}t + 1 \ if \ 0 \le t \le T \tag{14}$$

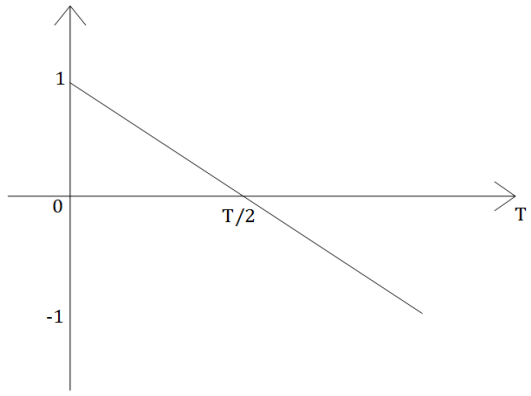

Figure 3: Inclined Type Force

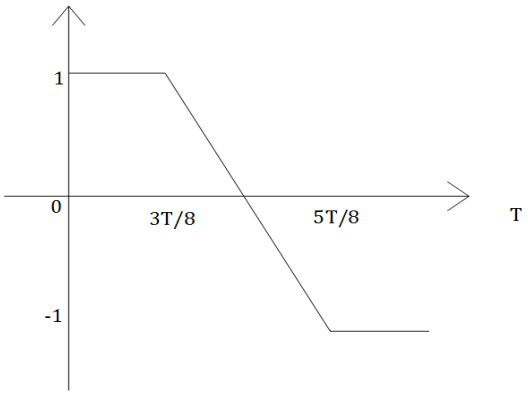

Figure 4: Quadratic type force

The force acting on the particle is

$$f(t) = mw^2 \sin\phi \times E(t) \tag{15}$$

The Fourier coefficient $a_0 = 0$, indicates that $\bar{E}= 0$, the other Fourier coefficients are

$$\begin{aligned} a_k &= 0 \\ b_k &= mw^2 \sin\phi(\frac{2}{k\pi}) \end{aligned} \tag{16}$$

So its potential energy function will be

$$\begin{aligned} U_{eff} = U + mw^2 \sin^2\phi \times \frac{1}{\pi^2}\sum_{k=0}^{\infty}(\frac{1}{k^4}) \\ = U + 0.1097mw^2 \\ sin^2\phi \end{aligned} \tag{17}$$

Where $\phi = 0, \pi$ and $arccos(-\frac{4.5579gl}{w^2})$ are the extremum of 17. After minimizing 17, we have following results.

- The downward position $\phi = 0$, is always stable.
- Vertically upward position $\phi = \pi$ is stable if $w^2 > 4.5579gl$.
- The point $\phi = arccos(-\frac{4.5779gl}{w^2})$ is unstable.

Quadratic Type force: Next, consider a quadratic type force: $Q(t) = Q(t+T)$ (shown is Figure 4), given by equation 18

$$Q(t) = \begin{cases} 1, & 0 \le t < \frac{3T}{8} \\ \frac{8}{T}(\frac{T}{2} - t), & \frac{3T}{8} \le t < \frac{5T}{8} \\ -1, & \frac{5T}{8} \le t < t \end{cases} \tag{18}$$

The force acting upon the particle is

$$f(t) = mw^2 \sin\phi \times Q(t) \tag{19}$$

The fast oscillating force in Fourier expansion is given as

$$Q(t) = mw^2 \sin\phi \sum_{k=1}^{\infty}(\frac{2}{k\pi} + \frac{8}{\pi^2 k^2}\sin k\frac{\pi}{4})\sin k(wt)$$

With the following Fourier coefficients

$$\begin{aligned} a_k &= 0 \\ b_k &= mw^2 \sin\phi \sum_{k=1}^{\infty}(\frac{2}{k\pi} + \frac{8}{\pi^2 k^2}\sin k\frac{\pi}{4}) \end{aligned} \tag{20}$$

So the effective potential energy function will be

$$\begin{aligned} U_{eff} = U + mw^2 \sin^2\phi \times \frac{1}{4}\sum_{k=1}^{\infty}\frac{1}{k^2}(\frac{2}{k\pi} + \frac{8}{\pi^2 k^2}\sin k\frac{\pi}{4})^2 \\ = U + 0.3856mw^2 \\ sin^2\phi \end{aligned} \tag{21}$$

Where $\phi = 0, \pi$ and $arccos(-\frac{1.2967gl}{w^2})$ are the extremum of above system. With 21, the stability of the system is given as

- The point $\phi = 0$, is always stable.
- The point $\phi = \pi$ is stable if $w^2 > 1.2967gl$.
- The nontrivial position $\phi = arccos(-\frac{1.2967gl}{w^2})$ is unstable.

So, it is observed that, the position $\phi = \pi$ is stabilized at lower frequency as compared to harmonic force.

Rectangular Type Force: Let's introduce the rectangular type force $R(t) = R(t+T)$, and the function $R(t)$ is T-periodic, given in 22, illustrated in Figure 5

$$R(t) = \begin{cases} 1, & 0 \le t < \frac{T}{2} \\ -1, & \frac{T}{2} \le t < T \end{cases} \tag{22}$$

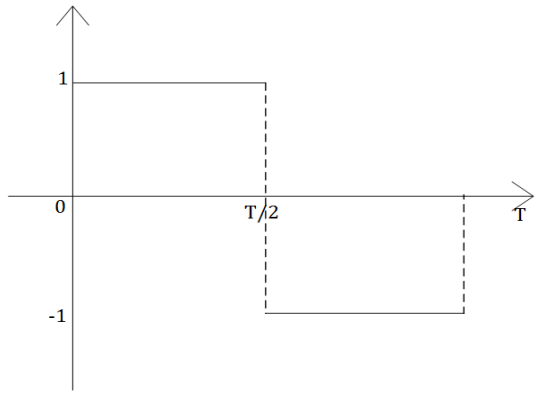

Figure 5: Rectangular type force

For vertical modulation, the force acting upon the particle is

$$f(t) = mw^2 \sin\phi \times R(t)$$

The Fourier coefficient $a_0 = 0$, shows that $\bar{f} = 0$, the other coefficients are

$$\begin{aligned} a_k &= 0 \\ b_k &= mw^2 \sin\phi(\frac{4}{2k-1}) \end{aligned} \tag{23}$$

Using above coefficients, the Fourier expansion is

$$R(t) = mw^2 \sin\phi \frac{4}{\pi} \sum_{k=1}^{\infty} \frac{1}{(2k-1)} sin(2k-1)wt$$

The effective potential energy is

$$\begin{aligned} U_{eff} = U + mw^2 \sin^2\phi \times \frac{1}{4}(\frac{16}{\pi^2})^2 \sum_{k=1}^{\infty} \frac{1}{(2k-1)^2} \\ = U + 0.4112mw^2 \\ sin^2\phi \end{aligned} \tag{24}$$

With the extremum at $\phi = 0, \pi$ and $arccos(-\frac{1.2159gl}{w^2})$. After minimizing 24, we have following results

- The point $\phi = 0$, is always stable.
- The point $\phi = \pi$ is stable if $w^2 > 1.2159gl$.
- The nontrivial position $\phi = arccos(-\frac{1.2159gl}{w^2})$ is unstable.

From the above examples, it is noticed that, at position $\phi = \pi$, the system is stabilized at lower frequency as compared to previous cases. The above results are summarized in Table 4.. It is also observed that, at nontrivial position, as area under the curve increases, the frequency of oscillation decreases. Harmonic and inclined type force has minimum area so they have maximum frequency as compared to rectangular type force.

5. Parametric Control

Next, a parametric control is defined on quadratic type force, to control the non-trivial position $\phi = \pi$. This force is also T-periodic, $Q_\epsilon(t+T) = Q_\epsilon(t)$. The control is defined for $0 < \epsilon < 1$. This ϵ-parametric force is defined as

$$Q_\epsilon(t) = \begin{cases} 1 & 0 \le t < \dfrac{1-\epsilon T}{2} \\ \frac{1}{\epsilon}(-\dfrac{T}{2}t + 1) & \dfrac{1-\epsilon T}{2} \le t < \dfrac{1+\epsilon T}{2} \\ -1 & \dfrac{1-\epsilon T}{2} \le t < T \end{cases} \tag{25}$$

and illustrated in Figure 6

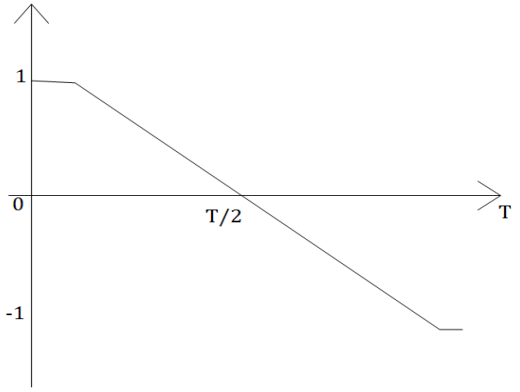

Figure 6: parametric quadratic type force

For vertical modulation the force acting upon the particle is

$$f_2(\phi, t) = mw^2 \sin\phi \times Q_\epsilon(t) \tag{26}$$

From 25, the other Fourier coefficients are

$$\begin{aligned} a_k &= 0 \\ b_k &= mw^2 \sin\phi(\frac{2}{k\pi} + \frac{8}{\epsilon\pi^2 k^2} \sin k\frac{\pi}{4}) \end{aligned} \tag{27}$$

Fourier expansion of oscillating force is

$$f_2(\phi, t) = mw^2 \sin\phi \sum_{k=1}^{\infty} (\frac{2}{k\pi} + \frac{8}{(\epsilon\pi^2 k^2)} \sin k\frac{\pi}{4}) \sin kwt\phi \tag{28}$$

So, the effective potential energy will be

$$\begin{aligned} U_{eff} = U + mw^2 \sin^2\phi \times \frac{1}{4\pi^2} \sum_{k=1}^{\infty} \frac{4}{k^4}(1 + \frac{1}{\epsilon k\pi} \sin\epsilon k\pi)^2 \\ = -mgl\cos\phi + mw^2 \sin^2\phi.A \end{aligned} \tag{29}$$

and

$$A = \frac{1}{\pi^2} \sum_{k=1}^{\infty} \frac{1}{k^4}(1 + \frac{1}{\epsilon k\pi} \sin\epsilon k\pi) \tag{30}$$

The effective potential energy 29 has extremum at $\phi = 0, \pi, arccos(-\frac{0.5gl}{w^2.A})$.
After minimizing 29, we have the following results

- The system is stable at point $\phi = 0$.
- If $w^2 > \dfrac{0.5gl}{w^2.A}$, then the system will be stable at $\phi = \pi$.

Table 1: Stability Comparison of different linear forces with harmonic force

External Force	**Position**	**Stability**	Position	**Stability Condition**
sin	0	always	π	$w^2 > 2gl$
Inclined	0	always	π	$w^2 > 4.5579gl$
Quadratic	0	always	π	$w^2 > 1.2969gl$
Rectangular	0	always	π	$w^2 > 1.2159gl$

Table 2: Stability condition of ϵ-parametric force at $\phi = \pi$

$0 < \epsilon < 1$	**Sum A**	**Stability Condition**
0.9	0.1320	$w^2 > 3.7879gl$
0.8	0.1607	$w^2 > 3.1114gl$
0.7	0.1956	$w^2 > 2.5562gl$
0.6	0.2357	$w^2 > 2.1213gl$
0.5	0.2793	$w^2 > 1.7902gl$
0.4	0.3239	$w^2 > 1.5437gl$
0.3	0.3664	$w^2 > 1.3647gl$
0.2	0.4029	$w^2 > 1.2400gl$
0.1	0.4287	$w^2 > 1.1663gl$

- The nontrivial position $\phi = arccos(-\frac{0.5gl}{w^2.A})$ is unstable.

The stability of the system for different values of ϵ is summarized in Table 2.
For $\epsilon = 0.9$, the infinite sum $A = 0.1320$, and the effective potential energy function is

$$U_{eff} = -mglcos\phi + 0.132mw^2 \sin^2 \phi$$

At the position $\phi = \pi$, the system is stable if the condition $w^2 > 3.7879gl$ is satisfied, and this value is much greater than all previous results. Next for $\epsilon = 0.8$, the infinite sum $A = 0.1606$, and the point $\phi = \pi$ is stable is $w^2 > 3.1114gl$, which gives much better result. Similarly, For $\epsilon = 0.1$, the system is stabilized at the same position with the condition $w^2 > 1.663gl$, and this result is better than all considered examples. From above discussed cases, it can be observed that, with the decrease in value of, infinite sum A is increased, thus stabilizing the system at relatively lower frequency at $\phi = \pi$.

It is also observed that, as $\epsilon \to 1$, the term $A \cong 0.1098$ and the system is stabilized at the position π with the condition $w^2 > 3.4.5537gl$, and this frequency is approximately equal to the inclined type force. Thus, the quadratic type force approaches to inclined type force as $\epsilon \to 1$, and the system is stabilized with much greater frequency and is not stable.

However, as $\epsilon \to 0$, the term $A \cong 0.4386$, and the position $\phi = \pi$ is stable if the condition $w^2 > 1.14gl$ is satisfied, and this frequency of oscillation is lower than rectangular type force. Observe the Table 2, the rectangular force fall between $\epsilon = 0.2$ and $\epsilon = 0.1$, and for the parametric force with $\epsilon = 0.1$, the frequency of oscillation becomes lower than that in case of rectangular type force. Hence, by defining the parametric control better results are achieved.

6. Conclusion

Using Kaptiza method of averaging for arbitrary periodic forces, the vertically modulated pendulum excited by periodic linear forces is stabilized at $\phi = \pi$ with the frequency w, that was found to be sufficiently less relative to the case of harmonic modulation. Moreover, the rectangular type force was found to be the best. The stability conditions at nontrivial position $\phi = \pi$ improves by defining a parametric control on some of the periodic piecewise linear forces. Hence, by adjusting the parameter, the system is stabilized with less oscillating frequency.

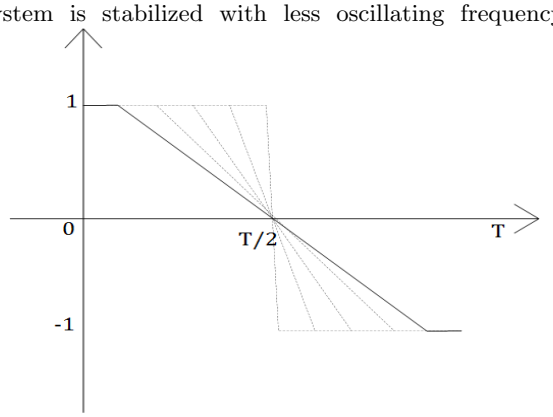

Figure 7: Quadratic type force for different values of ϵ

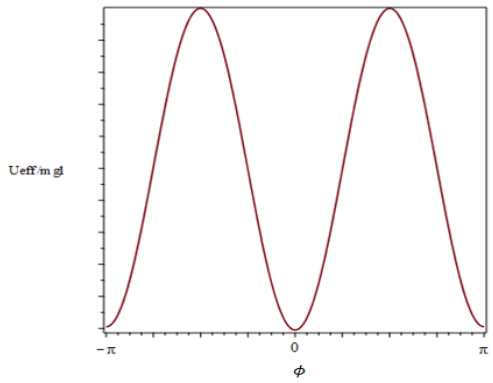

Figure 8: U_{eff} is minimum at $\phi = \pi if w^2 > 1.14gl$

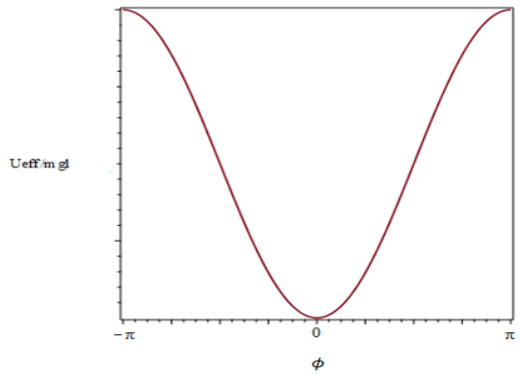

Figure 9: U_{eff} is always minimum at $\phi = 0$

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Secure Routing in Mobile Ad hoc Network - A Review

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Abstract

MANET is a wireless ad-hoc network which includes mobile nodes. In MANET mobile refers to the movable nodes which can change their location frequently. MANET is a network which has no central infrastructure; it is a self-managing and self-configuring network. In MANET devices can be heterogeneous like laptops, mobiles, PDAs, etc. Due to the mobility of the nodes and no infrastructure mobile ad hoc network can be used in disaster and emergency situations. Mobile ad-hoc network has the features of dynamic topology, multi-hop routing, energy constraint and easy setup. The nodes in the MANET work as a both host and a router, to make routes in the network. Due to all these flexible features of MANET there are many security vulnerabilities arise. In MANET routing is a main concern due to the mobility and the node work as a router. The security of the routing layer is essential because if any attack interrupts the communication security of whole network can be compromised. There are different types of attacks in MANET: internal attacks, external attacks, active attacks and passive attacks. The attacks of network layer are identified in this paper. Some routing protocols are used for the security of MANET like SAODV, SRP, SEAD and Ariadne etc. In this paper, we present a review of routing attacks and their possible solutions for example, how to avoid f these attacks.

Keywords: *Mobile ad-hoc network, Routing, Attacks, Security*

1. Introduction

One of the emerging technologies of wireless networking is Mobile Ad-Hoc Network, which is an infrastructure free network. There is no central management it is a self-organizing and self-configuring network. In Mobile ad-hoc network, nodes are movable. They can freely move in any direction [1]. Due to these features of MANET, this network can be used in military battlefields, emergency, Commercial Sector, Medical Service and disaster recovery situations. Nodes in MANET not only work as a host but they are also functioning as a router. Nodes include the mobile devices, laptops, PDAs and other handheld devices [2]. In Ad-hoc network nodes depend on the batteries or other resources of energy.

Network topology in MANET is dynamic. When the network change, the nodes have to maintain the routing dynamically according to the network. There are many security challenges for MANET due to no central infrastructure and the dynamic topology [2][3]. Different types of attacks can easily occur in the ad-hoc network like internal attacks, external attacks, active, and passive attacks. In this paper, we described routing layer attacks and there solutions how to avoid these attacks. Three types of routing protocols are used in ad hoc network: table driven, on demand and hybrid protocols [4]. Some routing protocols are used for the security of the ad-hoc network like SEAD, SAODV, and SRP etc. Intrusion detection system, watchdog and some other methods are described for securing the routing layer in ad hoc network.

The paper is arranged as follows. Section 2 presents MANET, section 3 Security attributes of MANET, section 4 Types of attacks in MANET, section 5 Routing protocols of MANET, section 6 Secure routing protocols, section 7 Secure mechanisms for routing attacks and section 8 describes conclusion

2. MANET

MANET is a collection of mobile nodes which are used for communication without any infrastructure. MANETs are used in sensor networks, personal area networks, and commercial sectors, military and emergency situations [5]. The characteristics of MANET are described below:

A. CHARACTERISTICS OF MANET

- No centralized infrastructure because of

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nodes self-managing and self-configuring capability.

- Flexibility in organization and rapidly setup network
- Nodes have multi-hop routing
- Dynamic network topology
- Nodes have energy constraints that affect the functionality of network.
- Nodes work as both host and a router
- Less bandwidth than the wired or infrastructure network.
- Nodes can be heterogeneous.
- Ad hoc network are exposed to many security threats.

B. VULNERABILITIES OF MANETs

Due to the some features ad-hoc network is more vulnerable as compared to wire or infrastructure network. Some of the vulnerabilities of MANET are listed below [6]:

1. **No Centralized Management**
   There is a no central manager that manages the network; every node is freely moved in the network. It is very difficult to monitor the traffic in the dynamic environment and the attacker can take the advantage of it.
2. **Dynamic Topology**
   Topology changes any time in the network. So there is a no trusting environment in the network. A malicious node can easily violate the network security.
3. **Power and Bandwidth Limitation**
   Due to limited bandwidth or capacity the signal can be affected by noise and interference. Ad-hoc network depends on the battery. So due to the limited power any node may turn to selfish.
4. **No Boundary**
   In wired networks gateways and firewalls are used for the security of the network but in ad hoc network there is no any secure boundary provided for the security of network.
5. **Cooperativeness**
   In MANET nodes are supportive to each other so a malicious node can take the advantage of it. And it can break the security of the network.

3. Security Attributes of MANET

Following are the some attributes for ensuring the security of the mobile ad-hoc network [7].

1. **Availability:** All the time nodes have to be available for the communication.
2. **Confidentiality:** It has to ensure that data is not revealed to illegal users.
3. **Integrity:** It has to be ensured that message is never changed during the transmission.
4. **Authentication:** Before communicating with any node, node has to be checked about the identity of that node.
5. **Non-repudiation:** The sender and the receiver cannot reject the sending and receiving information.

4. Types of Attacks In MANET

Following types of attacks can occur in MANET:

- Internal Attacks
- External Attacks
- Passive Attacks
- Active Attacks

Internal Attacks

Internal attacks are directly hits on a network nodes and connection between these nodes. The node which exists in the network forwards the wrong routing data to the other nodes .It is complex to identify this attack because these attacks arises due to most trustworthy nodes [8].

External Attacks

These attacks are not legally part of that network. Main purpose of attacker in external attacks is to cause congestion in network, broadcast false information of routing and interrupt the operation of entire network [9]. There are two important types of these attacks:

Passive Attacks: MANETs are more susceptible to passive attacks. The passive attack does not change the data spread inside a network. But it comprises unauthorized "listening" to network movement. In Passive attacks the attacker takes valued info in targeted networks. Valued information like node hierarchy as well as network topology is found. The attacker's objective is to attain data that is being transferred [10]. It is difficult to find out passive attacks as the process of network itself doesn't get affected. In order to overcome these attacks, powerful encryption algorithms are used to encrypt the data being transmitted. Monitoring, eavesdropping and traffic analysis are examples of passive attacks.

Active Attacks: These types of attacks are executed by malicious nodes. Active attack includes alteration

of data or may create wrong information. These attacks prevent messages route between different nodes in a network [11]. These attacks can be internal or external. In this attack, attacker attempts to interrupt the route of system or change the system resources. An attacker inserts malicious packets in a network for implementing active attack.

ATTACKS ON DIFFERENT LAYERS

Several attacks in MANET occur and we are classifying these attacks on the basis of protocol stack. But we will mainly focus on attacks at network layer. Attacks are listed in Table 1 [12].

ATTACKS AT NETWORK LAYER

It is very difficult to identify attacks on network layer because in MANET each node is associated with one another via hop-by-hop. Each single node takes decision about path to send packets, due to this way malicious node easily attack on that network. The main reason behind attacks on network layer is to insert malicious node between paths of sender to receiver or grasp traffic of network. Due to this way the attacker may generate routing hoops to form critical congestion in network. Different kinds of attacks are identified as discuss below.

1. **Blackhole Attack:**
   It is a type of attack in which malicious node claims route that is effective and smallest to target node and after that secretly drips data and monitor packets when they transmit via it [13]. Due to this shortest route created by attacker blackhole starts making fake packets by changing total and number of series of transmitting protocol message. The malicious node that is used in sending data packets towards destination instead of sending those is called blackhole node. This malicious node answers to request of each route by falsely declaring that this is a new route towards destination.
2. **Wormhole Attack:**
   In this attack, a malicious node collects data packets from one place to other malicious node through tunnels in similar network above an elevated speed wireless link. The tunnel occurs among two attacker nodes is denoted as a wormhole. Tunnels exist between two malicious nodes. That's why it is called as tunnelling attack [14]. When attacker keeps packet of data at one place, transmits those packets to alternative place, routing is interrupted.
3. **Sinkhole Attack:**
   In sinkhole attack malicious node presents false information of routing to create itself as definite node and obtains entire traffic of network. After getting network traffic, it changes the confidential information. The attacker node attempts to interest in confidential data from close nodes.
4. **Rushing Attack:**
   Rushing attacks are generally against on-demand routing protocols. When compromised node receives a route demand packet from resource node, it overflows the packet in all over the network earlier any other nodes which similarly get the similar route demand packet can respond [15]. In this attack, nodes only retransmit the initially request accepted to find out all route and ignore all others. When initially a route is discovered, the attacker enters in a network through messages request. If attacker's messages reach initially, attacker will be included in route discovery procedure.
5. **Replay Attack:**
   In replay attacks, a malicious node keeps command on messages of further nodes and retransmits them [21]. This is because topology is not static in MANET's; it transform's commonly due to movement of nodes. Due to this reason nodes must keep record of their tables of routing of declared routes.
6. **Link Spoofing Attack:**
   A malicious node transmits or presents the fake information of route to disturb the operation of routing. In this attack, malicious node influences the data or traffic of routing [16].
7. **Sybil Attack**
   In Sybil attack, attacker might create false characters of number of extra nodes. Sybil attack contains a malicious node that is declaring multiple identities. In this attack, a malicious node creates itself as a huge number other than individual node. This attack could be easily disturbed routing, distributed storage algorithms and system of fault tolerant. This is a critical attack because every single node depends on several intermediary nodes for communication.

5. Routing Protocols in MANETs

1. **Table Driven or Proactive Routing Protocols:**
   In Table driven protocols, every node consists of one or more routing table which contains the routing information from every node to all other nodes in the network. Different tables maintain this routing information. So, when the topology changes the nodes circulate the updated information all over the network. So, tables consist of consistent and updated routing information [17]. Table driven protocols use proactive technique. So, when there is a need to forward a packet, it follows the routing information table for route. Proactive protocols include clustered gateway switch routing, wireless routing proto-

Table 1: Attacks on Different Layers

Layers	Attacks
Application Layer	Repudiation, Data Corruption, Viruses and Worms
Network Layer	Wormhole, Black hole, Sinkhole, Rushing attack, Link Spoofing, Sybil, Replay
Transport Layer	Session Hijacking, SYN Flooding
Physical Layer	Jamming, Interception, Eavesdropping, Tempering
Data link Layer	Traffic Analysis, Monitoring, Disruption
Multi- Layer	Denial of service, Impersonation, Replay, Man-In-The-Middle

col, destination sequenced distance vector routing and optimized link state routing.

2. **On Demand or Reactive Routing Protocols:**
   On demand, routing protocols not stored the routing information. These protocols make the route between the source and destination while, it is Necessary. The route is generated on the demand of the source, when it has to communicate to the destination node [18]. Some reactive protocols are Ad-hoc on demand distance Vector routing, dynamic source routing, and temporally ordered routing algorithm, etc.

3. **Hybrid Routing Protocols:**
   Both proactive and reactive protocols have some pros and cons. Hybrid protocols use the both schemes proactive and reactive for the efficient routing. These protocols involve Zone routing protocol. Table 2 shows some strengths and weakness of protocols [19].

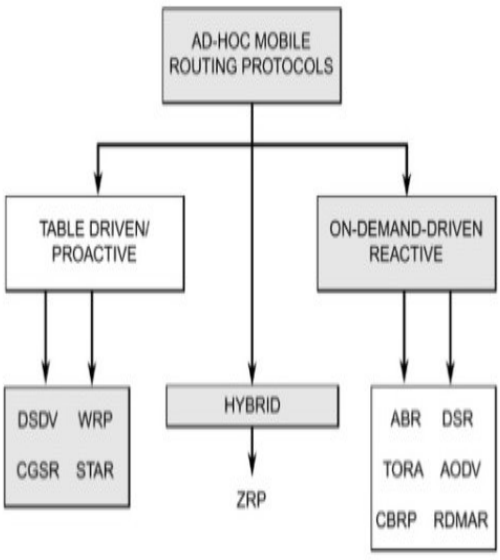

Figure 1: Routing Protocols in MANET

6. Secure Routing Protocols

1. **Ecure Adhoc on Demand Distance Vector Routing (SAODV):**
   SAODV is a reactive protocol that is based on the AODV protocol. It secures the routing messages by using the digital signatures and authenticates the RREQ and RREP messages. This protocol used asymmetric cryptography, hash function are used for getting the integrity. And digital signatures provide the authentication and non-repudiation. This protocol has a robust security mechanism that is very secure and provides a full featured security.

2. **Authentication Routing for Adhoc Network (ARAN):**
   This protocol uses asymmetric cryptography and provides end to end authentication. A trusted Certification Authority provides the public key, IP address and timestamp to the node before starting the communication. The harmful nodes can't start attacks because it requires the authentication certificate from the trusted certificate authority. Timestamp is defining the time when the certificate is created and when it will expire. Some attacks are possible that are Denial of Service attacks due to the negotiated nodes. The sharing nodes transmitted the route requests that are unnecessary over the network. These unnecessary requests give chance to attacker for attack in the network and it can cause overcrowding there by compromise the functionality of network [20]. Before the packets broadcasting to the next stage and checked for validation, every packet is authenticated in the network by using public keys. Intermediate node cannot reply; only the destination node can reply which is authenticated. ARAN prevents different attacks like spoofing attack, table overflow and black hole, because it has a solid cryptography mechanism and features.

3. **Secure Routing Protocol(SRP):**
   Secure routing protocol is based on hybrid (ZRP) protocol and other reactive routing protocols. This protocol used symmetric cryptography; Security Association is maintained by using the shared keys between the nodes. Packet includes the two identifiers: Query sequence number and

Table 2: Advantages and Disadvantages of Protocols

Type of Protocols	Advantages	Disadvantages
Proactive	1. Each node maintains the routing information before it is needed. 2. Minimizes the end-to-end delay of sending packets by updating the routing information.	1. These protocols are not good for large area networks. It has to maintain the information of each node in the table. 2. More overhead waste the limited bandwidth. 3. Not appropriate for highly mobile networks.
Reactive	1. Routes are only built when they are needed. 2. Scales to medium size networks with moderate mobility. 3. Decreases control overhead and power consumption.	1. Delay occurs due to the Source node has to wait for the route to be built earlier starting the communication.
Hybrid	It provides the advantages of both proactive and reactive, protocols. It decreases the overhead of proactive and decrease the delay of reactive.	In large routing, it gets the disadvantages of proactive protocols, and for small routing get the disadvantage of reactive

random query identifier. The route reply MAC provides integrity protection for the route reply packets. The query identifiers are used by intermediate nodes to check for replay attacks. If a query identifier matches one used in the past, the intermediate node discards the query packet. In network, many queries are received from around for measuring the frequency of these queries using nodes that take part in the process of route discovery and keep the question rate [21]. So the malicious nodes have lower importance for taking part.

4. **Secure Efficient Adhoc Distance Vector (SEAD):**
SEAD was established to provide routing security by symmetric cryptography and it is based on DSDV (Destination Sequence Distance Vector) and also has a function that is One-Way Hash to verify the route updating mechanism. For providing security to table driven protocols is difficult for it but providing security to on demand protocols is much easier for it. No attacker can attack in this network because it is using longer sequence numbers. It gives the verified security to packets for avoiding the wormhole attack using the Hash function, by retransmitting the packets from one place to another [21]. All packets reach their destination safely. Tunnelling, black hole and denial of service attacks are possible.

5. **Ariadne:**
It is an on demand (reactive) routing protocol which is based on DSR protocol. It uses authentication for the routing messages. Shared secrets between the nodes and digital signatures are used for performing the authentication. It also uses hashing for verifying that no intermediate node is missing or removing from the path. Ariadne based on timestamps that record time of any event and it controls some threats like modification and spoofing [22]. By using the source paths, avoided routes loops because packets will not send into loops. Secure protocols can categorize in two categories prevention and detection as Figure 2.

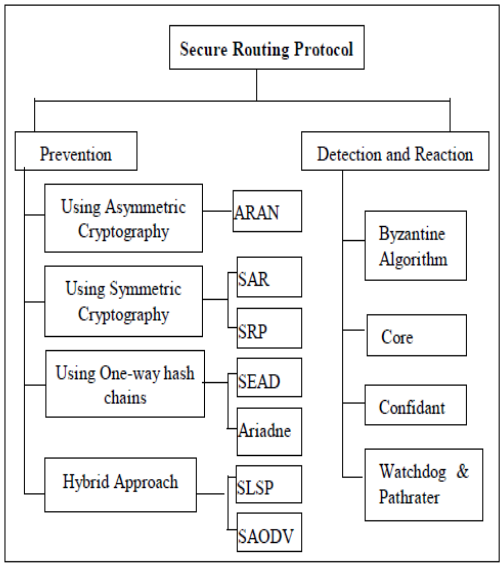

Figure 2: Secure Routing protocols

7. Security Mechanisms For Attacks

1. **Watchdog and Pathrater:**
Watchdog and pathrater are the two techniques which are used to secure the routing between the source and destination. Watchdog is used to check the transmission and misbehaviour of the

nodes. The node sends the packets to its next node and keeps this information in its buffer. The job of the watchdog is to check that whether the neighbour node forwards the packet or not. If the watched packets are the same with the packets that in the buffer, the node is not malicious. But if the node not forwards the packet and the number of abuses exceeds the threshold value, it considers that node is distrustful. Then watchdog forwards this message to the other nodes about the mischievous node. Then the other nodes check this message and this information is also sent to the pathrater. Pathrater is used to assign the rate to the nodes. Rating is done according to the behaviour of the node. So,when the malicious node is identified ,pathrater assigns the rate to this node by -100.Pathrater informs the protocols for avoiding this node and remove this node . Pathrater remove the unreliable paths and provide the new secure paths for sending the packets.

2. **Location Based Method for Link Spoofing Attack:**
   In this attack, the attacker node distribute wrong links with the other nodes to disturb the functions of routing layer. In ad-hoc network there are MPRs (Multipoint Relay nodes) that are used for spreading the messages among the nodes. If one of the node as a MPRs is selected and this is a malicious node, it can alter the data packets and disturb the network. To remove this attack time stamp and GPS (Global Poisoning system) with cryptography is used. Every node is linked with time stamp and location based GPS. All nodes share its location data among all the nodes through GPS [23]. So, due to the location data, attacks are easily identified by checking the distance among the nodes.

3. **Solution for Wormhole Attack:**
   In this attack, attacker gets the packet at one place and tunnels these packets to another place in the network. Some methods are proposed to avoid this attack like IDS, signal processing techniques and to make changing in the hardware design. A packet leash is a protocol that is used as a solution for wormhole attack. The sender inserted the information in the packet for controlling the distance of transmission, and some information is included to limit the lifetime of packet. At the receiving side the receiver verifies that whether the packet travels the same distance according to the information included by the sender or not [24]. This protocol needs information of location and synchronized clocks. Sector method and directional antennas are also used for avoiding this attack.

4. **Black Hole Attack Solution**
   In black hole attack, the attacker showing an optimal route to the node and gets the packets when the nodes sending request. Then it can change the packets. Many packets are lost in this attack and also cause denial of service (DoS). To prevent this attack different routing protocols are proposed for security such as SAR and SAODV. In Security aware ad-hoc routing protocol (SAR) a route discovery method is used and a trust level is added into the rushing request packets. The other nodes that are intermediary receive a packet with trust level. If the trust level is fulfilled, the node will handle the packet and spread it to neighbours, otherwise dropped. Secure Adhoc on Demand Distance Vector Routing protocol (SAODV) is also used as a solution for this attack. It uses some techniques in routing that are central key controlling, digital signatures for node level authentication and to lessen the modifying node checks a hash chain.

5. **Rushing Attack Solution**
   In rushing attack, the attacker sends many messages in the network for flood of packets. If the node receives message firstly from attacker, Then the node rebroadcasts its request for route discovery. Then it becomes very difficult for the nodes to discover the usable/non-attacking route. Different mechanisms are proposed to prevent this attack Secure Neighbour Detection, Secure Route Delegation, and Randomized ROUTE REQUEST forwarding. These techniques work together to defend this attack. When the sender node sends a Route Request to the neighbour node that is within the range, it allows the neighbour node to forward the request after signs a Route Delegation message. And then the neighbour node signs an Accept Delegation message after determining that the sender node is within the range. With the help of these techniques, the connection of neighbourhood between nodes can be conformed and ensured. Rushing Attack Prevention (RAP) protocol is also used to protect the network from rushing attack. Figure 3 shows the comparison which protocol provides security against these attacks [25].

8. Conclusion

Due to dynamic topology and no infrastructure MANET has many security challenges. This paper describes the different types of attacks of MANET, security attributes of MANET and our main focus on the security of the network layer in MANET. This paper identifies the attacks of network layer like wormhole attack, rush attack, Sybil attack and black hole attack, etc. Different protocols are described in this paper that provide security at the network layer. Some secure mechanisms are reviewed in this paper like watchdog and other solutions against some attacks are described. We present a review of attacks and their solutions in MANET how can avoid these attacks.

Protocol	Provide protection from Attacks						
	Type	Wormhole	Link spoofing	Replay attack	Black hole	Rushing Attack	Sybil Attack
SAODV	Reactive	No	Yes	Yes	Yes	No	Yes
SEAD	Proactive	Yes	No	No	No	No	No
ARAN	Reactive	No	Yes	No	No	Yes	No
Ariadne	Reactive	Yes	Yes	Yes	Yes	No	Yes
SRP	Hybrid	No	Yes	Yes	Yes	Yes	No

Figure 3: Comparison of Protocols

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Online Support Services in e-Learning: A Technology Acceptance Model

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Abstract

The development in the Information and Communication Technology in the contemporary digital age is rapidly changing the dynamics of the communication industry. The integration of technology in education is especially open and distance learning sector has given rise to e-leaning, which is the technology driven mode of education. Due to this emerging nature of the phenomenon, the students' ability to accept and respond to online support services is important for the success of e-learning system. This paper investigates the attitude of the students towards online support services at the Allama Iqbal Open University (AIOU), Pakistan, using Technology Acceptance Model. The AIOU is the second largest distance learning institute of the world. A questionnaire was adopted and customized from the previous studies to collect the feedback from the students. The feedback from 220 students was collected using the said questionnaire. The statistical techniques using the descriptive statistics and linear regression were applied to analyze the data. The results show a positive attitude of students towards the online support services. The regression analysis elaborates that there is a significant influence of the "perceived usefulness" of online support services on "behavioral intention". Furthermore, the regression analysis shows a significant influence of the "ease of use" on "behavioral intention".

Keywords: *Technology Acceptance Model (TAM), E-learning, "Ease of use", "Perceived Usefulness"*

1. Introduction

E-learning is the process of teaching via computers, the Internet and media technologies. It includes computer software based training, World Wide Web-based learning and broadcast media based learning [1]. The electronic mode uses Information and Communication Technology (ICT) to deliver the instructions [2]. These instructions are digitized using audio, video and multimedia technologies. The e-learning has become the need of learners of the present age. However, new issues are arising because technology is changing rapidly, affecting every field of life [3]. New models of e-learning are needed that can engage learners by catering their needs and styles of e-learning [4] through effective online support services.

The online support services deliver the course instructions by using web portals and Learning Management Systems (LMS). LMS is a specially designed application which provides a platform for executing online support services to distant learners [5]. The course instructions can be uploaded by the instructors that can be downloaded by the students, anywhere and anytime. The communication can also be established by using synchronous and asynchronous mode of instructions [5]. The synchronous mode is the real-time interaction in which students, as well as teachers, are present. Audio/Video conferencing and chat discussions are the synchronous forms of communication. Asynchronous is offline communication between teachers and students in the form of email, and forums, etc. [6]. Both synchronous and asynchronous interactions are the basic building block of communication in an e-learning system; however; a successful online system requires acceptance of emerging tools and technologies by the relevant users. The success of any technology-based service is dependent on its acceptance which can be measured by employing the technology acceptance models and framework that analyze users' intention of using new systems and applications. The important models of technology acceptance as reported in the literature review are Unified Theory of Acceptance, and Use of Technology (UTAUT), Diffusion of Innovation (DOI), and Technology Acceptance Model (TAM) [vii]. The TAM has been widely used to find user acceptance, willingness, attitude, behavioral intention about the new technology and online support services which are

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affected indirectly by the perception of usefulness and ease. Keeping importance of technology transformation in view and implementation of e-learning this paper analyzes personal beliefs of "Perceived Usefulness" (PU), "Perceived Ease of Use" (EOU) and "Behavioral Intentions" (BI) about online support services in e-learning initiated at AIOU, Pakistan.

2. Related Work

TAM has come out from the Theory of Reasoned Action (TRA) about human behavior [7]. It deals with the level of acceptance of Information Systems by analyzing the behavior and intentions of concerned users [8]. The Davis defines EOU as a degree of belief according to which a user will not be scared of any physical exertion while using a new technology system. The PU is conceptualized as a degree of belief according to which a user will be able to enhance his/her performance while using a new system [8]. Both the parameters are the basic building block of TAM theory and can predict the attitude of individuals towards using a new system. The attitude affects the "Behavioral intention" (BI) towards using a new system or application [9].

In the case of e-learning, the likelihood of using the support services depends upon the attitude of students towards computer-based systems [10]. It implies that if the online system is user-friendly and easy to operate, it may result in increasing the interaction level [11]. There is a number of external variables that can be used with TAM to investigate the learner's intention towards e-learning system [12]. The important variables include personal profiles of learners, organizational parameters, characteristics of e-learning systems and access to ICT devices. These variables influence PU though EOU depending upon the degree of beliefs that impress the learner's decision towards online support services provided. The user interface of LMS and web portals can play an important role to strengthen the Human-Computer Interaction (HCI).

The study of [13] highlighted that organizational policies, training of using online systems and interface are important in the adoption of LMS in the higher education institutes. The study investigated the effect of social networking, performance & effort expectancy and infrastructure towards the acceptance of LMS in the higher institutes in Kenya. The research described in [14] has analyzed the "behavioral intention" of students towards using e-learning applications. The study revealed that self-efficacy is the most important motivational factor towards e-learning "behavioral intention". The study [15] reviewed the acceptance of e-learning in developing countries. The study showed that social factors and motivation have a strong impact on intention towards the usage of e-learning systems.

The research [16] evaluated the parameters that influence the acceptance and usage of e-learning in educational institutes of New Zealand. The results highlighted that personal profiles and organizational parameters are both important towards the adoption of learning online. The research [17] evaluated students' attitude in relation to TAM while using e-learning. The study found that attitude has a substantial role in e-learning acceptance among students enrolled in University in Malaysia. The regional characteristics in terms of localized parameters are also found as an important factor in its acceptance. The acceptance level will be increased if the learning system will be developed after considering its user's local learning needs and requirement.

It is concluded that the rapid developments and expansion in modern technology has posed many challenges regarding its acceptance among potential users [18]. Different theories and models have come up to analyze user behaviors. TAM is more important as it has widely been used to analyze the student's feedback in many technologies enable learning paradigm. The previous studies have shown strong empirical results to prove the validity of TAM. Social media is also one of the areas which have been explored to study the learning impact on student's behavior using TAM [19]. The systematic literature view has also concluded to use the TAM in new learning dimensions [20].

3. Proposed Model

The three online support services are selected to find their "perceived usefulness" and "ease of use" for encouraging students' "behavioral intention".

A. *Quality of Digital Contents*
Digital Contents are an important part of an e-learning system. The digital contents comprise course tutorials, assignment, activities, questions, FAQS and announcements etc. Due to the geographical distance between students and teachers the quality of digital contents is very important. These contents must match with the course objectives and the learning outcomes. The content may effectively contribute to self-paced learning of the students if it conforms to the quality standards.

B. *Uploading and Downloading of Contents*
There are heterogeneous Internet connections available to students. These connections are dependent upon various parameters like efficiency, reliability, user-friendly interface, and error handling. Any complexity in the process may confuse the students [21]. A student requires seamless and error-free services for downloading the digital contents. Therefore, the "behavioral intention" is related to "ease of use" and "usefulness" of uploading/downloading.

C. *Asynchronous/synchronous interaction*
The synchronous and asynchronous interaction provides a communication mechanism between teachers and students and services departments like ad-

mission, examination, etc. The communication should be reliable and fast for the prompt reply to the distant students. If synchronous and asynchronous interaction meets the students' expectations, it may result in increasing the degree of belief of "ease of use" and "perceived usefulness" and motivation.

4. Proposed Hypothesis

The high degrees of PU and EOU can result in more confidence of students towards online support services while participating in e-learning activities [22]. This study, therefore, considered the important parameters reported in the literature review for the formulation of the research hypothesis. The statement form of the hypotheses are given below and the symbolic form is shown in figure 1.

[H1] Uploading and downloading of digital contents will have a significant influence on "perceived usefulness" of online support services.

[H2] Uploading and downloading of digital contents will have a significant influence on "ease of use" of online support services. [H3] The quality of digital contents will have a significant influence on "perceived usefulness" of online support services.

[H4] The quality of digital contents will have a significant effect on "ease of use" of online support services.

[H5] The asynchronous and synchronous interaction will have a positive influence on "perceived usefulness" of online support services.

[H6] The asynchronous and synchronous interaction will have a positive influence on "perceived ease of use" of online support services.

[H7] The "perceived ease of use" will have a positive influence on "perceived usefulness" of online support services.

[H8] The "perceived usefulness" will have a positive influence on "behavioral intention" of using online support services.

[H9] The "perceived ease of use" will have a positive influence on "behavioral intention" of using online support services.

5. Research Methodology

A. Sample

A survey was conducted from the students of AIOU, Pakistan to evaluate the application of TAM on online support services. The AIOU is the second largest open university of the world in terms of number of students. The university is in the transformation phase of converting distance learning programs into modern e-learning based mode [23].

The survey was distributed to Computer Science students studying at AIOU. It was comprised of questions about online support services on 5 – Point Likert scale. These questions were developed on the basis of e-learning initiatives taken at AIOU [23] and previous research of analyzing information systems using TAM [24 - 27].

The final questionnaire was comprised of 23 items to measure the six constructs Digital Content Quality (DCQ), Uploading/Downloading UD, Asynchronous/ Synchronous Interaction (ASI), "Perceived Usefulness" (PU), "Perceived Ease of Use" (EOU), "Behavioral Intention to use" (BI). The survey questionnaire also comprised the demographic items that indicated the age, gender, employment and accessibility to computer & Internet. The convenience sampling technique was used to collect feedback from the target population.

B. Data Analysis

The data collected with the help of questionnaire has been analyzed quantitatively. The demographics results are shown in Table 1. It shows that males are 80% and females 20%. The age of respondents ranged from 15-20 to 30 +, however majority of the respondents belongs to 26 – 30 age group. The majority (59.1%) are engaged in jobs. PCs with Internet connections are also available to a large majority of respondents.

Table 1: Demographics

Variable	Frequency	Percentage
Gender		
Male	176	80%
Female	44	20%
Age Group		
15-20	57	25.9%
21-25	26	11.8%
25-30	73	33.2%
30+	64	29.1%
In service		
Employed	130	59.1%
Non-employed	90	40.9%
Personal Computer		
Yes	220	100%
No	0	Nil
Internet Facility		
Yes	211	95.9%
No	9	4.1%

C. Descriptive Statistics

The Descriptive statistics of six variables can be seen in Table 2. The mean value is high i.e. closer to 4 which indicate the influence of variables on acceptance of online support services. The SD values are approximately equal to 1 which indicates small deviations from the mean value.

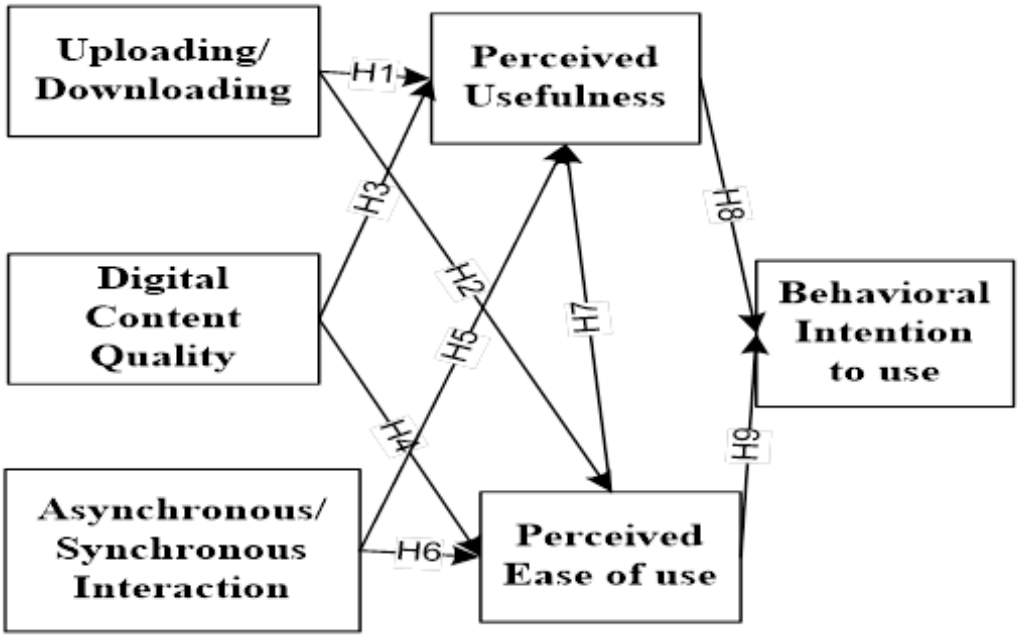

Figure 1: Proposed Model with Hypothesis relation

Table 2: Descriptive Statistics

Variables	Mean	Std. Deviation
EOU1	4.04	0.840
EOU2	3.90	1.066
EOU3	3.87	1.061
EOU4	3.88	1.070
PU1	3.93	1.074
PU2	3.85	1.056
PU3	3.88	1.172
PU4	3.93	1.042
BI1	3.88	1.185
BI2	3.74	1.148
BI3	3.77	1.054
UD2	3.84	1.121
UD3	3.80	1.081
UD4	3.75	1.087
UD5	3.80	1.061
DC1	3.93	0.953
DC2	3.93	1.002
DC3	3.80	1.064
DC4	3.94	0.972
ASI4	3.76	1.118
ASI5	4.06	0.894
ASI6	3.87	1.052
ASI7	3.92	1.022

D. Reliability Measures

The internal reliability and construct validity of the questionnaire were evaluated to determine the stability and suitability of the questions. There are 220 entries of data and for this range of data the factor loading values should be 0.5 least and the Cronbach's alpha range should be between 0.6-0.7, 0.8 is considered as strong reliability between variables while below 0.6 is as weaken. The below table shows that total 23 variables are being used for factor analysis, having 0.825 Cronbach's alpha value for the reliability of these variables that is much efficient to prove that.

Table 3: Cronbach Alpha

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Item	No. of Items
0.825	0.824	23

E. Appropriateness of Data (adequacy)

The appropriateness and sphericity of data were calculated through KMO and Bartlett's test. Kaiser-Meyer Olkin test value was 0.790 (close to 0.8), and therefore, considered as good [28]. The significance value was less than 0.05 that showed the data appropriateness for further factor analysis.

Table 4: KAISER-MEYER-OLKIN (KMO) Measure

KMO Measure of Sampling Adequacy		0.790
Bartlett's Test of Sphericity	Approx. Chi-Square	1.367E
	Df	253
	Sig.	0.000

F. Factor Loading

The factor loading matrix is shown below in Table 5 which indicates the relationship of the questions with

factors. Higher the loading across the item, stronger is its relationship with the factor [29]. The values are between 0.5 and 0.7 which indicate a strong relationship among the items. The Exploratory Factor Analysis (EFA) was calculated by computing the eigenvalues. The factors with eigenvalues greater than 1 are considered significant and others are discarded on the basis of Kaiser latent root criterion [29]. Six factors with eigenvalues greater than 1 were extracted which resulted in 57% of the variance.

Table 5: Factor Loading

	1	2	3	4	5
EOU1	0.800				
EOU2	0.824				
EOU3	0.758				
EOU4	0.582				
PU1					0.497
PU2					0.530
PU3					0.723
PU4					0.771
BI1					
BI2					
BI3					
UD1		0.646			
UD2		0.740			
UD3		0.749			
UD4		0.686			
DC1			0.566		
DC2			0.699		
DC3			0.656		
DC4			0.715		
ASI1				0.706	
ASI2				0.722	
ASI3				0.646	
ASI4				0.562	
%Variance explained	12.806	11.001	8.531	8.474	8.413
Cumulative percentage	12.806	23.807	32.337	40.811	49.224

6. Analysis of Proposed Hypothesis

To test the first hypothesis (H1), the regression analysis was carried out as shown in Table 6. Table 6 shows that uploading and downloading of contents is positively related to "perceived usefulness". It reveals that strong relationship between online support services and "perceived usefulness". The p-value shows that H1 is supported and accepted.

Table 7 shows that uploading and downloading of contents is positively related to "ease of use". It reveals that strong relationship exists between online support services and "ease of use".

Table 8 shows the regression analysis for H3. The result shows that digital content quality has a significant influence on "perceived usefulness".

Table 9 shows the regression analysis for H4. The result shows that digital content quality (DC) has a significant influence on "ease of use".

Table 10 shows the regression analysis for H5. The result shows that asynchronous and synchronous interaction has a significant influence on "perceived usefulness".

Table 11 shows the regression analysis for H6. The result shows significant influence of asynchronous and synchronous interaction on "perceived ease of use".

Table 12 shows regression analysis for H7. The result shows that there is significant influence of "perceived ease of use" on "perceived usefulness".

Table 13 shows the regression analysis for H8, which elaborates that there is significant influence of "perceived usefulness" of online support services on "behavioral intention".

Table 14 shows the regression analysis for H9. The result shows a significant influence of "ease of use" on "behavioral intention".

The results show that effects are significant and all the hypotheses have been supported. The previous studies have also shown significant effect of EOU on PU and BI [9, 30]. The students of e-learning have shown positive attitude towards online support services. The "perceived usefulness" has a greater significant correlation with usage behavior than "perceived ease of use". This led to hypothesize that "perceived ease of use" may be a causal predecessor to "perceived usefulness" rather than a direct determinant of technology usage [9]. The positive feelings of the users to "ease of use" are certainly linked with its sustainability [31]. The proposed model with hypothesis results is shown in figure 2.

Table 6: Regression Result For H1

H1	B	Standard-Error(B)	T	P	R Square
UD→PU	0.167	0.064	2.504	<0.013	0.028

Table 7: Regression Result For H2

H2	B	Standard-Error(B)	T	P	R Square
UD→EOU	0.205	0.067	3.091	<0.002	0.042

Table 8: Regression Result For H3

H3	B	Standard-Error(B)	T	P	R Square
DC→PU	0.159	0.075	2.375	<0.018	0.025

Table 9: Regression Result For H4

H4	B	Standard-Error(B)	T	P	R Square
DC→PU	0.160	0.079	2.395	<0.017	0.026

Table 10: Regression Result For H5

H5	B	Standard-Error(B)	T	P	R Square
ASI→PU	0.329	0.075	5.146	<0.000	0.108

Table 11: Regression Result For H6

H6	B	Standard-Error(B)	T	P	R Square
ASI→EOU	0.160	0.074	2.393	<0.018	0.026

Table 12: Regression Result For H7

H7	B	Standard-Error(B)	T	P	R Square
EOU→PU	0.537	0.060	9.407	<0.000	0.289

Table 13: Regression Result For H8

H8	B	Standard-Error(B)	T	P	R Square
PU→BI	0.267	0.069	4.086	<0.000	0.071

Table 14: Regression Result For H9

H9	B	Standard-Error(B)	T	P	R Square
EOU→BI	0.124	0.075	1.840	<0.067	0.015

7. Conclusion

The global development in the technological era is posing many challenges but at the same time it is opening many avenues of advancements. The distance learning is also affected by the technological developments and shifting towards electronic mode. E-learning is based on online support services, which rely on uploading/downloading of digital contents and interaction through synchronous/asynchronous modes [32]. The role of student support services and its acceptance have become more important [33 - 35]. As in other relevant studies, this study revealed that TAM can effectively be used to predict and understand users' perception on using e-learning support services.

The results have shown favorable response from the respondents. The hypotheses on "behavioral intention" of using online support service are supported. The results also show that there is a positive readiness for implementation of e-learning systems in Pakistan. The research study shows that high acceptance rate of technology for online teaching and learning can lead to enhance the learning capacity and knowledge level of students. Results also show that uploading and downloading of contents is positively related to "ease of use". The digital content quality has a significant influence on "perceived usefulness". Furthermore, asynchronous and synchronous interaction has a significant influence on "perceived usefulness". The result also elaborate that there is significant influence of "perceived ease of use" on "perceived usefulness" and a significant influence of "ease of use" on "behavioral intention". The students of e-learning have shown positive attitude towards online support services. The "perceived usefulness" has a greater significant correlation with usage behavior than "perceived ease of use". This led to hypothesize that "perceived ease of use" may be a causal predecessor to "perceived usefulness" rather than a direct determinant of technology. Furthermore, this research model may also be applied by other education institutions for evaluating their readiness regarding technology enabled learning.

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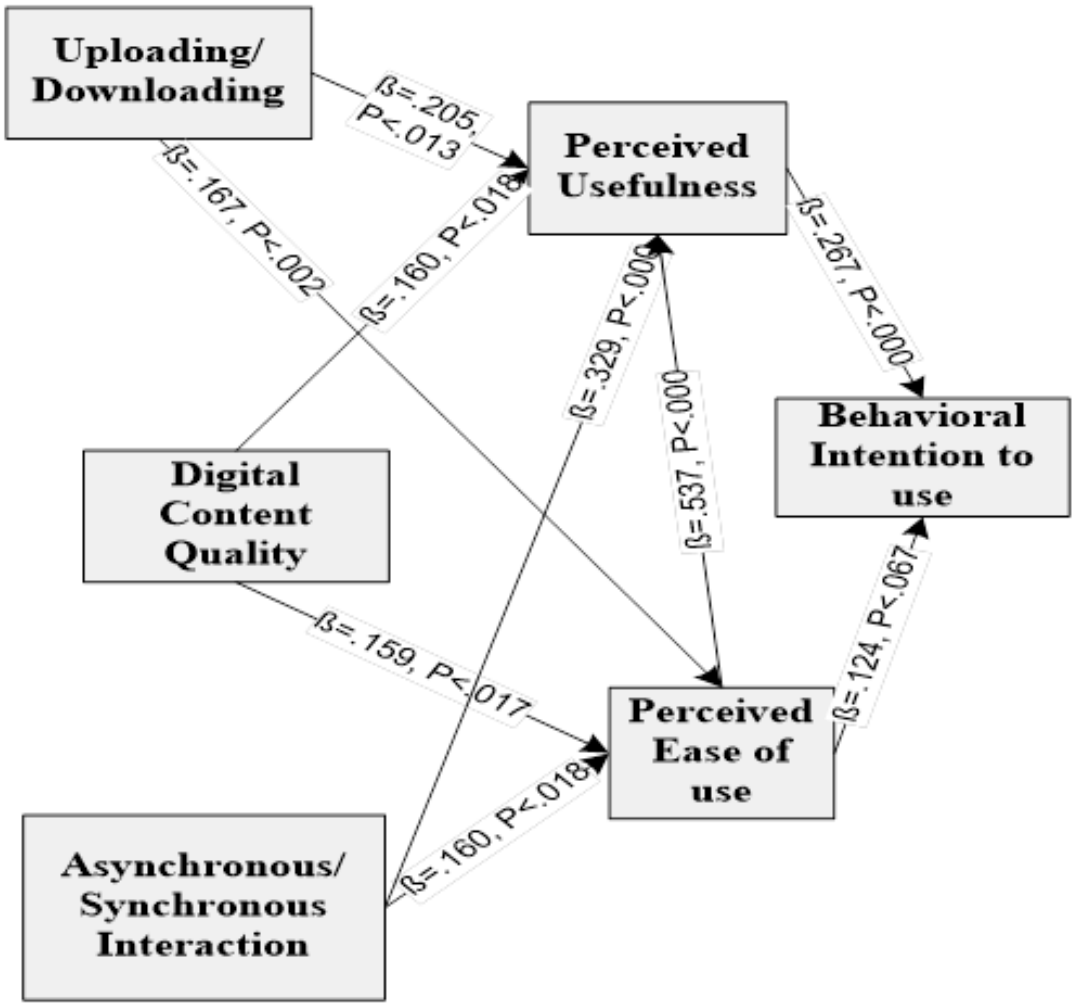

Figure 2: Proposed Model with Hypothesis results

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Developing Sindhi Text Corpus using XML Tags

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Abstract

Sindhi language being one of the oldest languages of the world, has still very limited use in digital age due to lack of digital contents. The use of corpus for each language has been extremely important in facilitating the natural language processing of its script. This research work addresses the issue of building corpus for Sindhi Language using XML based Tagging. The tree based XML tag structure is designed to develop Sindhi Corpus that has two main nodes namely metadata and Sindhi Document which contains the main text. The Corpus developed contains a detailed metadata tags to represent Sindh language, documenting each relevant component of the corpus. The final corpa would be further used in various Natural language applications for Sindh language.

Keywords: *Corpus, Sindhi, Sindhi Corpus, Natural Language Processing, XML*

1. Introduction

Sindhi language is a widely spoken language based on Arabic script with similar cursive ligatures and written from right-to-left consisting of 52 characters [1] [2]. Sindhi language is considered as the second most popularly written and spoken language, after Urdu, in Pakistan. Even though Sindhi is an old language with vast amount of literature and written resources. However, there are very insufficient computational material and digital coprus available for Sindhi Language to create efficient NLP applications.

Natural Language Processing applications always require a huge collection of Corpus data for the language. A corpus is simply collection of large amount of structure and unstructured text for a language. The well-defined structural format is created to store and categorize the text in large datasets, allowing the computational processing and application development. This structured datasets facilitates the statistical analysis and grammatical validation of the script, along with other applications of NLP [3] [4].

Corpus are considered as one of the key prerequisites for and obligatory component for developing any Natural Language Processing applications such as, Spell checkers[2][5], Machine Learnings, Speech-to-Text, Text-to-Speech, OCR, Translation, Transliteration, etc. [6]. Due to this, there is huge need for developing a Sindhi language corpus which is also publicly available for everyone to use.

XML has always been a key technique for designing a structure for developing Corpa of various languages [7] [8] [9] [10]. XML is a very flexible language due to its tag-based structure, which allows the developer to easily extract the required and desired information from the structured XML document. Developing Sindhi corpus in XML would enable rule-based tagging's, and structured designing of Corpa, allowing an easier reusability of the corpus along with broader dissemination to various NLP applications.

Since Corpus is extremely essential for any language for NLP application, a huge amount of work from various aspects has been done to develop corpus for various different languages. Primarily, a project named EMILLE was developed consisting of multilingual corpora for South Asian languages [10]. Similarly, Urdu corpus was developed containing 18 million words by the Center for Research in Urdu Language Processing (CRULP) [11]. CRULP has also developed and released Online Urdu Dictionary (OUD) containing 120,000 records of Urdu corpus with 80,000 words dictionary words [9]. Whereas, Bank of English Corpus was developed to help the dictionaries [8]. On the other hand, Hindi Corpus was designed by IIT Bombay to facilitate the NLP development of the language [13] along with EMILLE corpus [12].

2. XML Structure for Sindhi Corpus

In NLP application development, XML tag-based structured format has been widely used to create structured

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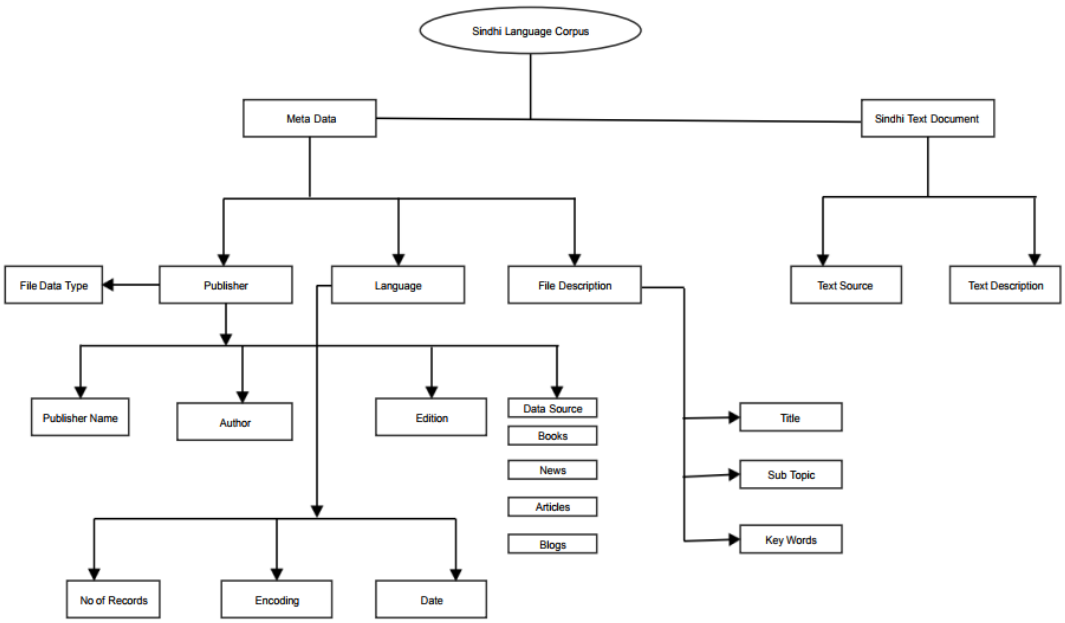


Figure 1: Proposed Model with Hypothesis relation

documents for processing and developing regional language applications [14]. For this purpose, XML has been used with custom tag to structure Sindhi text in a formalized Corpus for various NLP applications. The tags for Sindhi Corpus based on XML have been segregated into two main sections consisting of Metadata tags and Sindhi Text Document tags. Each is then further divided to contain more detailed information in its sub- tags.

A. Sindhi Corpus Structure

The XML based Sindhi Corpus structure has been divided into two main sections at the top-most level with 'Metadata' tag containing tags related to the original source information related to the actual text and document. The 'Sindhi Text Document' tag is second top-most tag containing the actual text from the source document. The full hierarchy of the XML tag structure for Sindhi Corpus is illustrated in Figure 1. Each Sindhi Corpa document will be stored with respect to this structure within XML tags.

B. Meta Data Header of Sindhi Corpus

Metadata is defined as the data about the data. Therefore, this main tag contains specific detail information related to the source document. This main section contains attributes such as "Title" of the document, "Sub Title" of Sindhi document, if any, "Topic" being discussed in the Sindhi document, "Sub Topic", "Book", "Author", "Edition", etc. The detailed sub-tag structure of the meta data section is shown in Figure 1.
The 'Sindhi Text Document' tag contains the source raw text information which is extracted from various sources including websites, newpapers, books, articles, etc. This tag contains further two sub tags that describe the text description of the source text and the actual text file under "Text Description" and "Text Document" respectively.

3. Sindhi Corpus Representations

There are two main custom tags defined after <sndhiLangCrps> as <sndMetaData> </sndMetaData> and <sndTextDoc> </sndTextDoc>, and the operator (+) shows that both custom tags have also child tags as define operator (+) in Figure 2.

```
<?xml version="1.0" encoding="UTF-8"?>
<sndhiLangCrps>
  + <sndMetaData>
  + <sndTxtDoc>
</sndhiLangCrps>
```

Figure 2: Super tags of <sndhiLangCrps> SLC(Sindhi Language Corpus

Figure 3 shows the main Sindhi Language Corpus Tag that contains to top-most sub tags Sindh Meta Data nd Sindh Text Document tags.

```
-<sndhiLangCrps>
      +<sndMetaData> </sndMetaData>
      +<sndTxtDoc> </sndTxtDoc>
</sndhiLangCrps>
```

Figure 3: Root and elements tags of sndhiLangCrps

A. Portion of SndMetaData

The tag of XML <sndMetaData> "Sindhi Meta Data" is the part of Sindhi corpus in data file which shows that the Sindhi data about its own data, it has child tags which also contains further information about the Sindhi document.

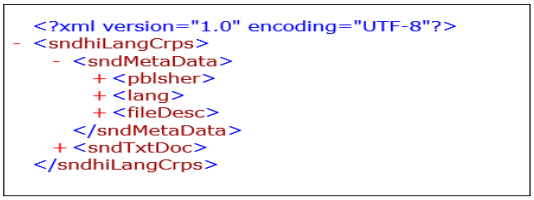


Figure 4: Elements and child tags of SndMetaData at SndhiLangCrps

In this figure 5 the elements tags of <sndMetaData> </sndMetaData> has been defined as <pblsher> </pblsher>, <lang> </lang> and <fileDesc> </fileDesc> and they have also sub child as per operator defines.

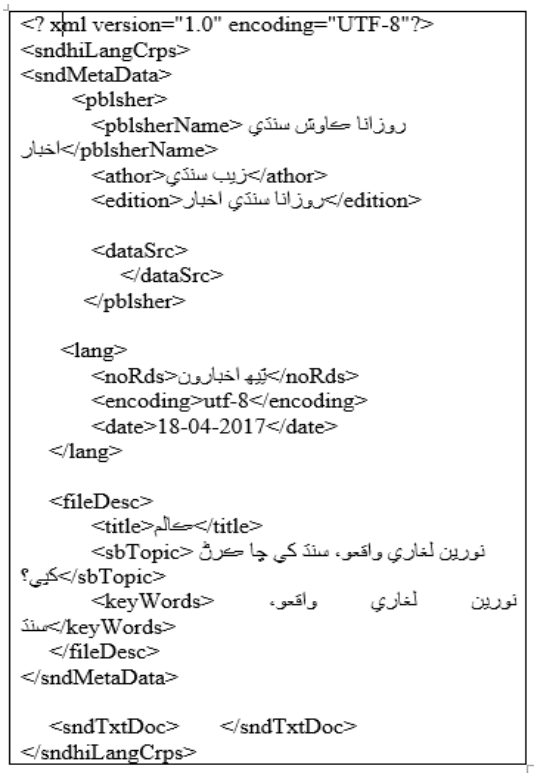


Figure 5: Sindhi XML Corpus with MetaData

Figure 6 shows another example of Publisher tags data for Sindhi Document. In this figure, the child tags of <pblsher> </pblsher> has been defined as <pblsherName> </pblsherName>, <athor> </athor> and <edition> </edition> custom tags. Accurate data also filled in that custom tags for the building of SLC, while the other tags are here in silent mod they have discussed in other figure and the operator (-) shows that specific tag is displayed with own child and no more child is hide.

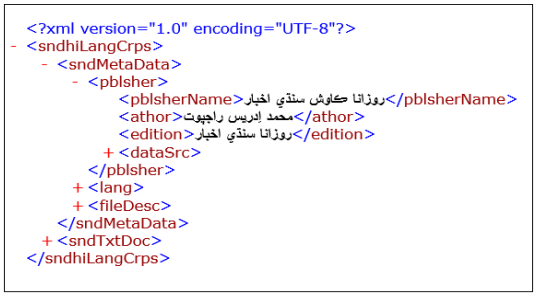


Figure 6: Data in publisher tag

The XML tag <sndMetaData> has three elements tags named as <pblsher> Publisher, <lang> Language and <fileDesc> File Description.

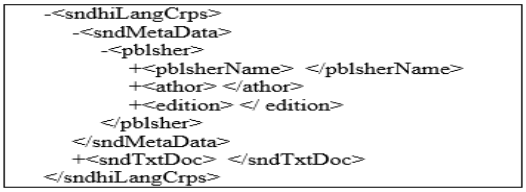


Figure 7: Elements and child tags of pblsher in SndMetaData at SndhiLangCrps

The publisher tag <pblsher> contains the information of publications, with describes its child elements as <pblsherName> "Publisher Name", <athor> "Author " , <edition> "Edition". The tag <pblsherName> shows the name of publisher, the tag <athor> tells the name of author while the tag <edition> describes the edition of publications.

Figure 8: Elements and child tags of pblsher with its child's elements edition in SndMetaData at SndhiLangCrps

The tag <pblsher> publisher is the child tag of Sindhi Meta Data <sndMetaData> while the tag <edition> Edition is the child tag of <pblsher> and <edition> tag

has its child as <dataSrc> “Data Source”, <books> “Books”, <news> “News”, <articles> “Articles”, <blogs> “Blogs”. These all are the sources of information which provide the complete data to edition and edition makes the complete to the publisher tag.

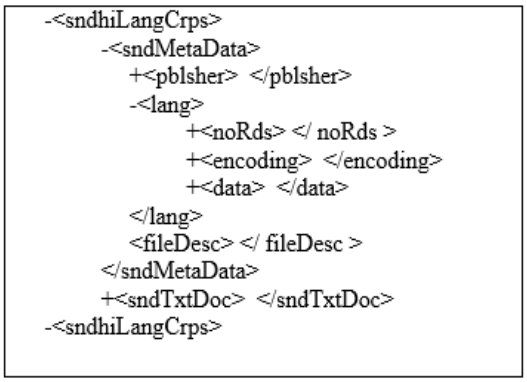


Figure 9: Elements and child tags of Lang in SndMetaData at SndhiLangCrps

The Language tag <lang> is the element tag of <sndMetaData> which has child tags like tag <noRds> “Number of Records”, <encoding> “Encoding”, <data> “Data”.

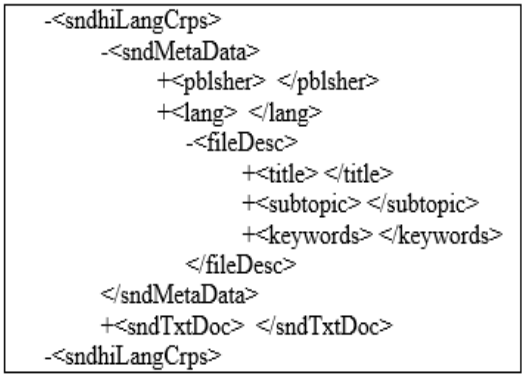


Figure 10: Elements and child tags of fileDesc in SndMetaData at SndhiLangCrps

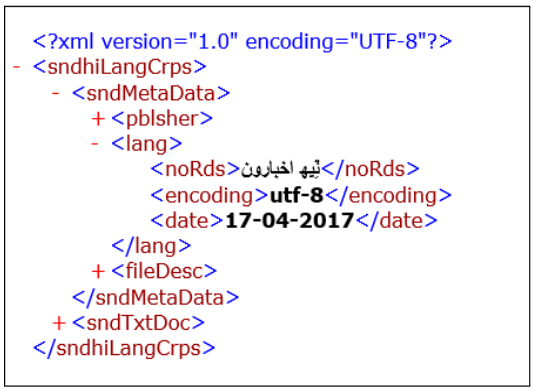


Figure 11: child tags of <lang> </lang>

Figure 11 uses the child tags of <lang> </lang> tags as <noRds> </noRds>, <encoding> </encoding> and <date> </date>. That tags have filled by accurate data while other tags are here silent to show the role of that tags in corpus linguistics.

File Description <fileDesc> is the element tag of <sndMetaData> tag consists of child tags as <title> “Title”, <subtopic> “Sub Topic”, <keywords> “Key Words”.

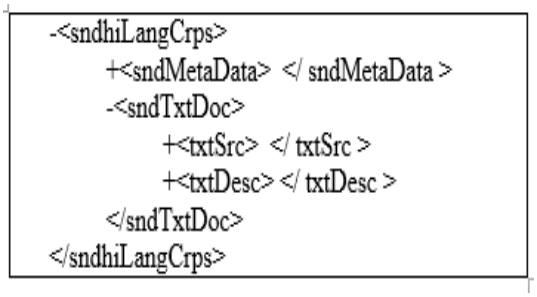


Figure 12: Elements and child tags of SndTxtDoc at SndhiLangCrps

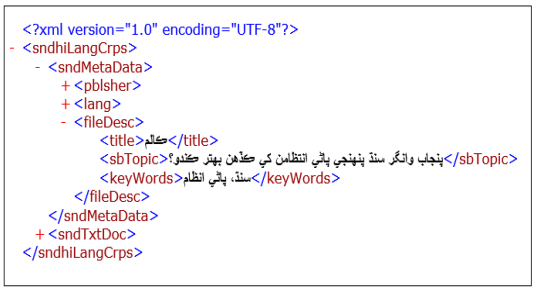


Figure 13: Element tags of <fileDesc> </fileDesc>

Figure 13 shows the sub tags of custom tag of <fileDesc> </fileDesc> as <title> </title>, <sbTopic> </sbTopic> and <keyWords> </keyWords>. All tags have assigned their own data.

B. Portion of Sindhi Text Document

The tag of XML <sndTxtDoc> “Sindhi Text Document” is the part of Sindhi corpus in data file, it has also child tags as <txtSrc> “Text Source”, <txtDesc> “Text Description”.

4. Sample Sindhi Corpus Document

The final Sindhi documents are initially created manually by extracting information form articles and saving them in XML tags as discussed [15]. A GUI form was designed that allowed the creating of XML document for Sindhi text as shown in Figure 14. Each entry was saved as an XML file as per rules and patterns discussed above.

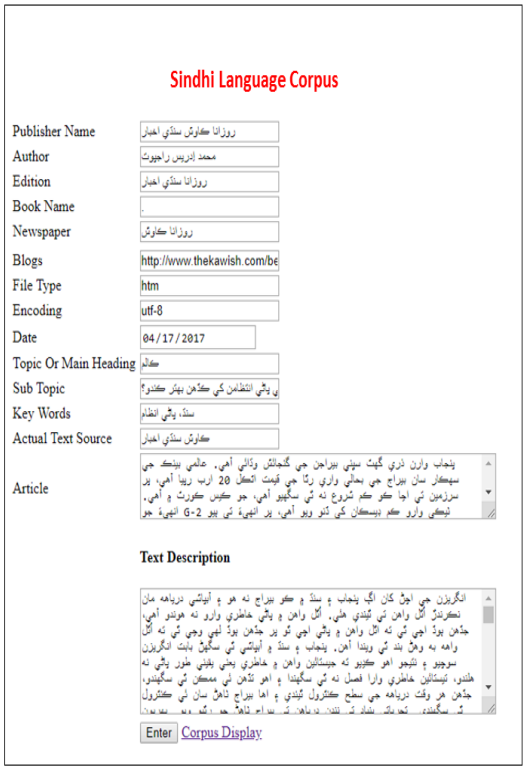


Figure 14: GUI form for creating XML document of Sindhi corpus

```
<? xml version ="1.0" ?>
<sndhiLangCrps>
 -<sndMetaData>
        -<pblsher>
                <pblsherName>Sindhi Text Book
        Board Jamshoro </pblsherName>
                <athor> Allah Bux Talpur, Sukhyo
                Khan Channa, Abdul Rehman Siyal,
                Dr.Abdul Majeed Memon,
                Haji Inayat-u-llah Zangejo </athor>
                <edition>Second </edition>
                <dataSrc> Secondary School
                Text Book</dataSrc>
                <books> Sindhi Text Book
                </books>
                <news> پرنٽنگ پريس ڪراچي ۾
                ڇپيو</news>
                <articles> هن ڪتاب جا سڀ حق ۽
                واسطا سنڌ ٽيڪسٽ بڪ بورڊ
                جامشورو وٽ محفوظ آهن
                </articles>
                <blogs> Sindhi Language
                Authority</blogs>
        </pblsher>
        -<lang>
        <noRds> اٺ ڀيرا سيڊ</ noRds >
        <encoding> utf-8 </encoding>
        <date> April -2012 </date>
        </lang>
       -<fileDesc>
                <title>سنڌي الف ڪتاب</title>
                <subtopic> فهرست</subtopic>
                <keywords>حمد، نعت،سبق
</keywords>
         </ fileDesc >
        </sndMetaData>
-<sndTxtDoc>
        <txtSrc> سنڌي الف ڪتاب </ txtSrc >
        <txtDesc> سبق پهريون
        (حمد)
        جو ٿون الله هيڪڙو واءِ پي وسار،
        ٿن ۾ تندُ تنوار سدا سيُڙين.
        </ txtDesc >
</sndTxtDoc>
</sndhiLangCrps>
```

Figure 15: Sample Sindhi XML document

The final version of each XML document of Sindhi corpus contain all the relevant information that could easily be read and processed for any NLP task as shown in Figure 15 to Figure 18.

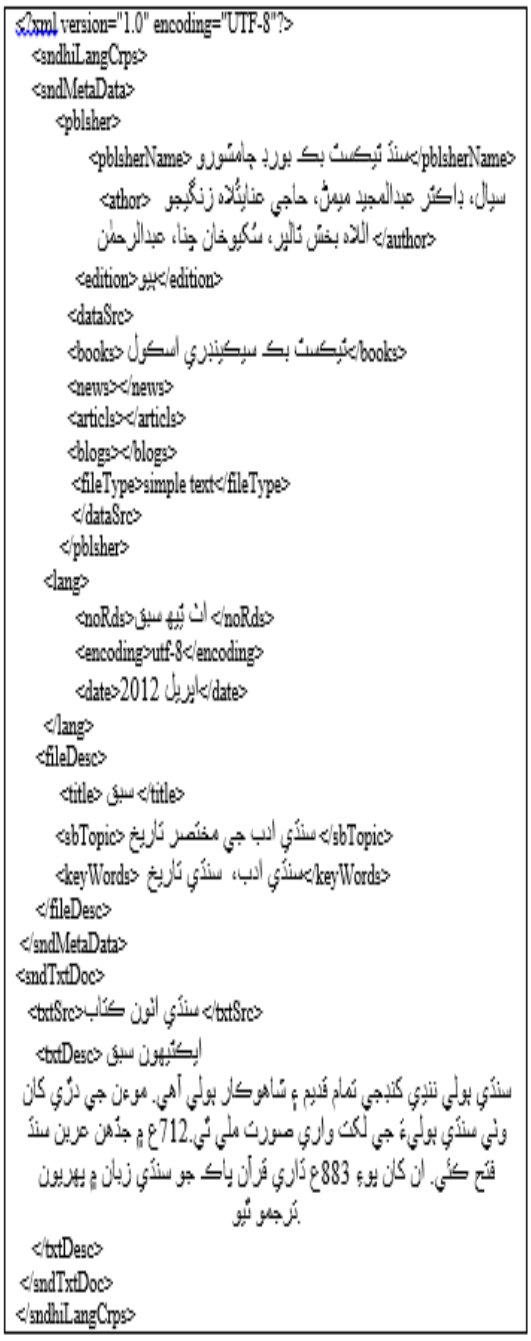
```
<?xml version="1.0" encoding="UTF-8"?>
<sndhiLangCrps>
        <sndMetaData>
                <pblsher>
                        <pblsherName> روزانا كاوش سنڌي
اخبار</pblsherName>
                        <athor>زاهده ڊيئو</athor>
                        <edition>روزانا سنڌي اخبار</edition>
                        <dataSrc>
                                <books></books>
                                <news>روزانا كاوش</news>
                                <article>ستر كالم</article>

        <blogs>http://www.thekawish.com/beta/epaper-
details.php?details=2018/July/12-07-2018/Page4/P4-5.jpg</blogs>
                                <fileType>jpg</fileType>
                        </dataSrc>
                        </pblsher>
                <lang>
                        <noRds>ٽيهه اخبارون</noRds>
                        <encoding>utf-8</encoding>
                        <date>07-12-2018</date>
                </lang>
                <fileDesc>
                        <title>كالم</title>
                        <sbTopic> ها ٽوڪي ايڪشن عوام جي
حالت تبديل ڪندي؟</sbTopic>
                        <keyWords> ايڪشن،
عوام،حالت</keyWords>
                </fileDesc>
        </sndMetaData>

        <sndTxtDoc>
                <txtSrc>كاوش سنڌي اخبار</txtSrc>
                <TxtDesc> هن وقت سنڌ ۾ جوندن جا منظر آهستي
آهستي واضح ٿيڻ لڳا آهن. اڳي ماڻهن ساڻ ان قسم جي صورتحال اميدوارن
لاءِ ٻيدا ن ڪئي هجي، جهڙي هنن جوندن ۾ نظر اچي رهي آهي. ماڻهو هن
پيري بانهون ڪنجيون وينا آهن، رڳو اميدوار جي اچڻ جي دير آهي
جينئن اُهي پُهچن ٿا ت وٺ يڪڙ جو ماحول ٻيدا ٿي وڃي ٿو ۽ ماڻهن ياران
اميدوارن کان سخت پُڇائا ڪيا وڃن ٿا. ماڻهن جي اهڙي سخت پُڇائي جهڙو
ماحول اڳ ڪڏهن ب نظر ن آيو.

</txtDesc>
</sndTxtDoc>
</sndhiLangCrps>
```

Figure 16: Sindhi XML Document 2



```
<?xml version="1.0" encoding="UTF-8"?>
  <sndhiLangCrps>
  <sndMetaData>
    <pblsher>
        <pblsherName> سنڌ ٽيڪسٽ بڪ بورڊ جامشورو</pblsherName>
        <athor> سيال، ڊاڪٽر عبدالمجيد ميمڻ، حاجي عنايتُالله زنگيجو
        الله بخش ٽالپر، سُکيوخان جتوئ، عبدالرحمٰن</author>
      <edition>ٻيو</edition>
      <dataSrc>
      <books>ٽيڪسٽ بڪ سيڪنڊري اسڪول</books>
      <news></news>
      <article></article>
      <blogs></blogs>
      <fileType>simple text</fileType>
      </dataSrc>
    </pblsher>
   <lang>
      <noRds>اٺ ٻيهه سبق</noRds>
      <encoding>utf-8</encoding>
      <date>اپريل 2012</date>
   </lang>
   <fileDesc>
     <title>سبق</title>
     <sbTopic>سنڌي ادب جي مختصر تاريخ</sbTopic>
     <keyWords>سنڌي ادب، سنڌي تاريخ</keyWords>
   </fileDesc>
</sndMetaData>
<sndTxtDoc>
  <txtSrc>سنڌي ادب ڪتاب</txtSrc>
  <txtDesc>ايڪتيهون سبق
سنڌي بولي ننڍي کنڊجي ٿمام قديم ۽ شاهوڪار بولي آهي. موهن جي دڙي کان
ملي سنڌي بوليءَ جي لکت واري صورت ملي ٿي.712ع ۾ جڏهن عربن سنڌ
فتح ڪئي. ان کان پوءِ 883ع ڌاري قرآن پاڪ جو سنڌي زبان ۾ پهريون
ترجمو ٿيو
  </txtDesc>
</sndTxtDoc>
</sndhiLangCrps>
```

Figure 17: Sample Sindhi XML Document 3

```
<sndMetaData>
  <pblsher>
    <pblsherName>روزانا ڪاوش سنڌي اخبار</pblsherName>
      <athor>محمد إدريس راجپوت</athor>
      <edition>روزانا سنڌي اخبار</edition>
          <dataSrc>
            <books></books>
                <news>روزانا ڪاوش</news>
                <articls>ستر ڪالم</articls>
    <blogs>http://www.thekawish.com/beta//images/2017/April/17-
04-2017/Page4/P4-2.htm</blogs>
    <fileType>htm</fileType>
      </dataSrc>
    </pblsher>
          <lang>
                <noRds>ٻيو اخبارون</noRds>
                <encoding>utf-8</encoding>
                <date>17-04-2017</date>
          </lang>

          <fileDesc>
                <title>ڪالم</title>
                <sbTopic> ٻنجاب واندگر سنڌ ٻنهنجي ٻاڻي
انتظامن کي ڪڏهن بهتر ڪندو؟</sbTopic>
                <keyWords>سنڌ، ٻاڻي انظام</keyWords>
          </fileDesc>
    </sndMetaData>

    <sndTxtDoc>
          <txtSrc>ڪاوش سنڌي اخبار</txtSrc>
          <TxtDesc> انگريزن جي اڃڻ کان اڳ ٻنجاب ۾ سنڌ ۾
ڪو ٻيراج نه هو ۽ آبپاشي درياهه مان نڪرندڙ اُٿل واهن ئي ٻُڌندي "هئي. اُٿل
واهن ۾ ٻاڻي خاطري وارو نه هوندو آهي، جڏهن ٻوڏ اچي ٿي نه اُٿل واهن ۾
ٻاڻي اچي ٿو ٻر جڏهن ٻوڏ لهي وڃي ٿي نه اُٿل واهه به وهڻ بند ٿي ويندا آهن.
ٻنجاب ۾ سنڌ ۾ آبپاشي ٿي سگهڻ بابت انگريزن سوچيو ۽ نتيجو اهو ڪڍيو نه
جيستائين واهن ۾ خاطري يعني يقيني طور ٻاڻي نه هلندو، تيستائين خاطري وارا
فصل نه ٿي سگهندا ۽ اهو تڏهن ئي ممڪن ٿي سگهندو، جڏهن هر وقت درياهه
جي سطح ڪنٽرول ٻُندي ۽ اها ٻيراج ذاهڻ سان ئي ڪنٽرول ٿي سگهندي.
تجرباتي بنياد تي ننڍن درياهن تي ٻيراج ذاهڻ جو رٿيو ويو. پهريون ٻيراج
راوي درياهه تي 1859ع ۾ مانٽويور نالي ذاهيو ويو، ٻيا ڪيترا ٻيراج معاون
درياهن تي ذاهيا ويا ۽ سنڌو درياهه تي پهريون ٻيراج سکر وٽ 1932ع ۾ ذاهيو
ويو. هاڻي سنڌو درياهه تي 6 ٻيراج آهن، ٿي سنڌ ۾ ۽ ٿي ٻنجاب ۾ ۽ معاون دريا
هن ئي ٻنجاب ۾ 10 ٻيراج آهن. اهي ٻيراج ڪافي پراڻا آهن، جن کي بحالي جي
ضرورت آهي. اڄو نه پيٽ ڪريون نه ٻنجاب وارا ٻنهنجي ٻيراجن جي بحاليءَ
لاءِ ڇا ڪري ڇڪا آهن، ڇا ڪن ٿا، ۽ اسان سنڌ وارا اُنهن جي پيٽ ۾ ڪٿي
"ٻينا آهيون؟ ٻنجاب جا سنڌو درياهه ئي ٿي ٻيراج آهن جناح، جتّما ۽ ٽونسا
</txtDesc>
</sndTxtDoc>
</sndhiLangCrps>
```

Figure 18: Sample Sindhi XML Document 4

5. Conclusion and Future Work

The use of corpus in Natural Language Processing is extremely essential and important. The Sindhi Language Corpus is designed using XML tags to facilitate the processing of Sindhi text for various NLP tasks. XML tags have been designed to provide maximum data facilitation and a long term usability of Sindhi Corpus. The tab structure is segregated into two main sections containing metadata and main source full document. The metadata is crucial part of any document, and so Sindhi corpus metadata also contains many sub tags to cater for all possible information of any document. The use of XML for Sindhi corpus has been very fruitful and has provided a platform to work on more processing of Sindhi Text.

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Effective Word Prediction in Urdu Language Using Stochastic Model

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Abstract

Word prediction and word suggestion is an important tools for writing contents in any language, in which the right word is predicted in a current context. Writing contents on English keyboards to produce other language contents is too hard and time consuming for everyone and requires more practice. To increase the typing speed especially in mobile and smart phones or for creating contents on social networks derived the need of this tool in every language. This paper presents a state of the art research for word prediction in Urdu Language (UL) based on stochastic model. Hidden Markov Model was implemented to predict the next state, while Unigram Model was also used to suggest the current state and the next hidden state, N-Gram Model was followed keeping N=2. The tool is developed to implement this model for Urdu Language (UL) and tested by regular and new URDU content writers to check their improvements in their typing speeds.

Keywords: *Word Prediction, Natural language processing, stochastic model, unigram, interpolation, markov model*

1. Introduction

Word Prediction (WP) is a significant task of Natural Language Processing (NLP) and probability theory. It is intended to predict the right word in a given context. Word prediction can be utilized in numerous applications. For instance, prescient content section frameworks, word consummation utilities, and composing helps [1] and [2]. Many prediction methods are available in IT industry. The well famous systems are T9(), eZiText(), iTAP(), and these systems are adopted by large smartphones companies. This paper presents a model, a word prediction application for Urdu language. After typing one word, the model gives a suggestion wordlist to a user which user wants to write and think about the next word. Since word prediction has always become important task for users to minimize their keystrokes while typing and provide suggestions to use different words according to the context. A typical way to handle and deal with this problem is to prepare and apply stochastic approach based on Hidden Markov Model (HMM) and Unigram Model (UM).

As there isn't any previous work done for Urdu Language (UL), the state of the art work presents a successful implementation for word prediction utilizing probabilistic model and selected techniques. N=2 is selected for the current state of suggested words. Probabilistic techniques have been applied on Urdu Language (UL) to obtain computable linguistic artifacts. Most of Pakistan's 190 million population can speak URDU but while typing they are not fluent and feel difficulty [3]. The study covers the following aspect which will target the technical community and make their work easy to make new applications for users on every platform by providing the features of this study in several ways like Desktop Applications, Mobile Applications, Cross Platform Applications, Web and Online Applications, etc.

Today all existing smartphone or portable devices have predictive keyboard [4]. This keyboard helps in typing by predicting the next word and completing word suggestion which aids in faster typing and time saving [5]. Although, sometimes results are sidesplitting as the keyboard is not perfect [6],to train soft keyword is not very difficult. [4] used word-predicting technology to suggest a text entry in soft keyboard, but this feature can generate incorrect suggestions – especially when typing is being done in another language or slang. There are also many little suggestions and prediction applications available, but those are for users who can run their applications on fixed platforms only.

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2. Literature Review

Various techniques and frameworks have been proposed for word prediction in the previous couple of decades. These techniques could be described through stochastic model and Markov Model (MM) predicting the future state with the help of unigram techniques. In [4] presented Urdu corpus character frequency analysis. The Monte Carlo Simulation performed with simulated annealing to optimize the keyboard layout. Moreover, the keyboard layout was augmented for speeding up the text entry from Urdu corpus lists to predict text. For justification purpose, the keyboard performance analysis was done. Carlo et al [7] presented a FastType prediction system based on statistical and lexical methods. [8], proposed an effective work derived from surface features for the accurate prediction of word. [9] presented a new approach called relational feature for predicting word. In which each word was treated as a word and then predicted in its context. [10] implemented stochastic model for the word prediction in Bangla language. They used a large corpus, reduced the chance of misspelling and implemented choices of the right word according to current context. [11] proposed a new technique for automatic word prediction based on content mining specially designed for the big data systems. Kenneth et al [12] introduced an extension for smartphone keyboard. When user tapped on keyboard, different phrase suggestions appeared on user keyboard. [13] presented string matching word prediction by implementing Morris Pratt algorithm. This technique was evaluated using text classification and several more techniques. [14] worked on crowdfunding websites (Entrepreneurs & Artists) and predicted different phrases through the study of different projects, analyzed predictive power of phrases and constructed dataset for phrase prediction. In [15], proposed a probabilistic driven model to predict word as well as phrase. They introduced FussyTree structure to address both problems.

2.1 Slow Typing Speed

Many significant challenges and issues are being faced in Urdu Language (UL) in Urdu typing. A Survey conducted by (10fastfingers) URDU typing speed is 50% less than the English typing speed that was just because of double characters per key on the keyboard which caused user to avoid the language for typing purpose and instead use another. Typing competition was conducted by (10fastfingers) for Urdu and English typing speed, the Urdu typist was around 70+WPM, and whereas in English typist's speed was about 160+ WPM.

2.2 Collecting Urdu Words

In this section, we discussed the problems faced in collecting Urdu words. We collected Urdu words from different sources [16], [17], and [3]. From a corpus of source-target sentence, we wrote many programs that perform different phases in order to extract only the Urdu syntax words. Firstly, for good predictive suggestion, collecting the words was a major challenge [18] and [4]. We designed little software for crawling, extracting, cleaning, counting and more to crawl the websites and then extracted only the Urdu syntax words, then cleaned all the other languages other than Urdu and then counted their occurrence on repeating to find out their frequency. We were able to find out 1.25Lac+ unique Urdu words that was a big data till now in its own category. Now for the other category of double words collection, we again crawled the internet and browsed to be able to find out about 0.5Lac+ double words with their own most used general collection. Two-big data helped us out to work further and gave the best performance that it could.

3. Procedure

3.1 Selecting Algorithm

Selection of algorithm was a challenging part, we can get our start by analyzing and writing many algorithms. We ended up with an optimized version of algorithm that would fulfill our need of output with the best utilization and artificial intelligence with work behind the screen and to make the intelligence better for front-end program to get experience that is more professional with the application.

3.2 Urdu Suggestion and Prediction

The writing breakdown of Urdu Language text can be eased by an "Intelligent" word predicting feature of word processing. Due to 50+ alphabet, and 50% of them being used with SHIFT keys, the range was controlled by reducing the keystrokes necessary for word typing. The word prediction monitored the user input as s/he types letter by letter and suggested the appropriate word list with beginning letter or contained the sequence of input letters [19] and [20]. The list was updated by input of each letter. The desired words were chosen from the suggested word list, which was being inserted in the cursor position in the ongoing sentence or text just by a single keystroke or selection. Usually, the list of words was numbered and could be entered by typing the respective number.

- Match typed word from the prefix of dictionary words
- Predict dictionary typed words that user just typed before
- Suggest wrong word that user type, but not present in the dictionary
- Get the frequency of the character to match them first
- Suggest the closed typed word again first

Table 1: Training Algorithm for Predicting Urdu Language Sentences

```
HashMap ← SingleWordDictionary
HashMap ← DoubleWordDictionary
List ← UserSingleWordDictionary
List ← UserDoubleWordDictionary
Initialize the data
If (User Type)
    Var ← All Text
Position ← Type Position
Var ← Last Char Before Caret
Dictionary (Last Char Is Alphabet)
    Var ← Get That Whole Word till Last Space
    Var ← Garb All the Text
    Array ← Extract All the Grams
    Dic ← Update The Runtime Dic
    Sort ← Sort as Per Frequency
    Find ← Match the Starting Word From Runtime Dic
    Find ← Match the Starting Word From Dic
    Extract ← Filter the Words from the DICs
    Final ← Make a Final List
    Show ← Return to the User
Else If (Last Char Is Not Alphabet)
    Do the Same About but With Double Word Dic
OnClosing, Save The Words.
Step 1: Initialize single & double Urdu words at class level.
Step 2: Check the text changed event in textbox.
Step 3: Get the caret position.
Step 4: Pick up the last char before caret.
Step 5: Check
IF last char is an alphabet, pick up that's alphabet.
ELSE IF last char is anything else then first pick up last full word.
Step 6: Get all the text from the text box.
Step 7: Split it with special char.
Step 8: Get all words in an array.
Step 9: if the last char is holding.
Step 10: Match that char with the starting from the runtime dictionary.
Step 11: Get some words that are in runtime dictionary not in main dictionary.
Step 12: Get some words that are in runtime dictionary and also in main dictionary
Step 13: Get some words that are in main dictionary
Step 14: Now get the position of the caret.
Step 15: Show the collected matched word list there.
Step 16: Now if the last word is holding.
Step 17: Match that word with the starting from the runtime dictionary.
Step 18: Get some words that are in runtime dictionary not in main dictionary.
Step 19: Get some words that are in runtime dictionary and also in main dictionary.
Step 20: Get some words that are in main dictionary.
Step 21: Now get the position of the caret.
Step 22: show the collected matched word list
```

4. Experimental Steps

In this section, the features and techniques of the methodology are discussed. The methodology is clear and straight as the intelligent words were built with the implementation of artificial intelligence, through which the user typed character and a list of suggestions to complete the word is available for the user. When the user types a completed word, then the next most probability holder word would be given to be fitted there so it could save time more than before with 99% perfect correction. The study ended up with an optimized version of the algorithm that would fulfill the need of output with the best utilization and artificial intelligence by working behind the screen as well to make the intelligence even better for user of front-end program to get experience that is more professional with the application.

4.1 Software Flow Diagram

The flow of working starts with the typing of the first character and moves forward with the subsequent input. Different states and different variations were considered and described with parallel conditions, activities and system functions to achieve the goal. Figure 1 shows the outlook view of algorithm.

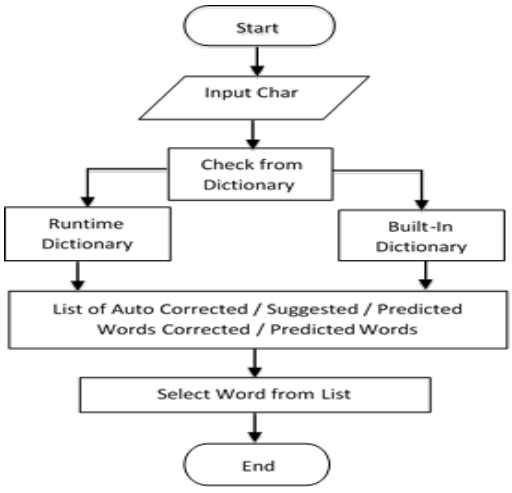
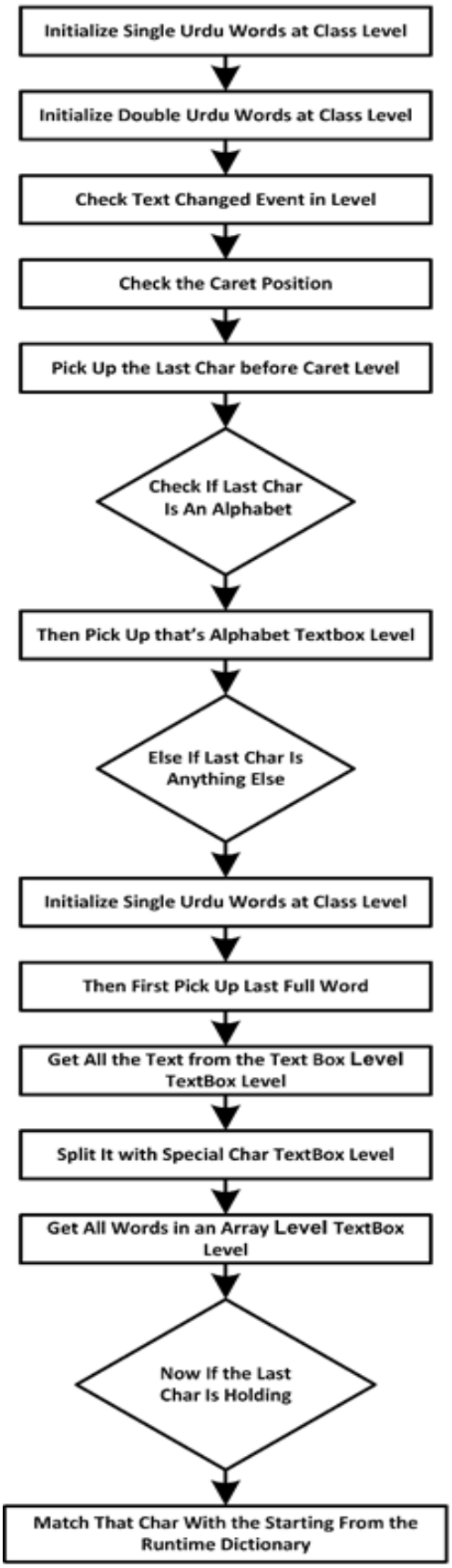


Figure 1: Representational Outlook of Idea

4.2 Diagrammatical View of Algorithm

The Diagrammatical view of the optimized version of the algorithm that would fulfill the need of output with the best consumption and artificial intelligence, with working behind the screen, which is mentioned above, is presented in Figure 2.



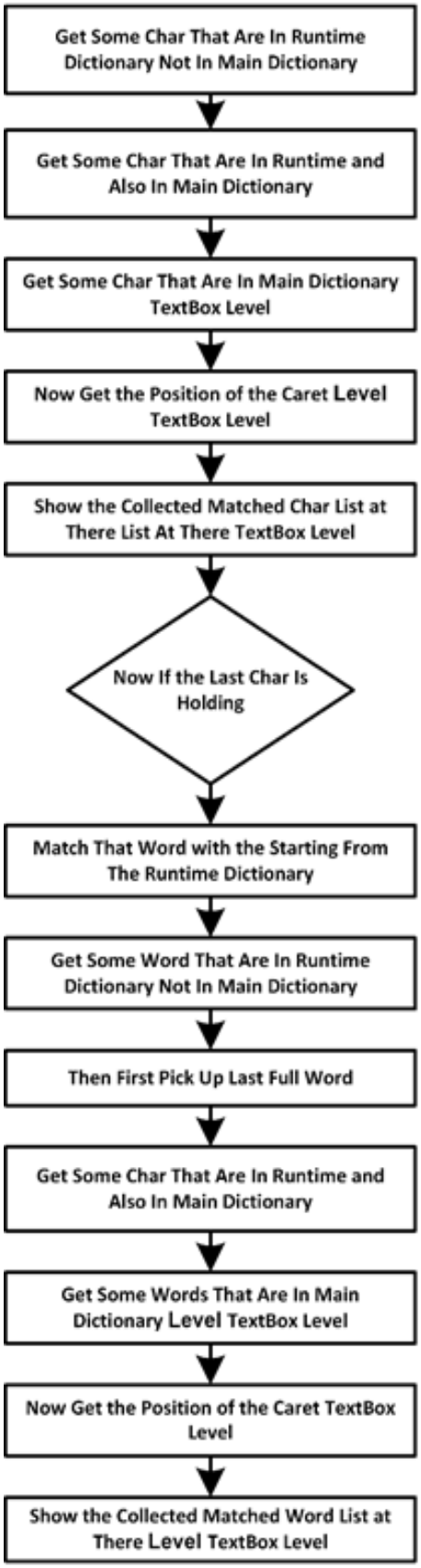


Figure 2: Flow Chart

4.3 Data Structure of UL

We used two data structures to maintain Urdu dictionary. We implemented word suggestion and prediction using unigram and bigram models. The list of the data structures was maintained and used for different purposes. It was needed to maintain a list of all unique words with associated index values in the Urdu corpus. HashMap was suitable, because I would keep the RAM compressed and clean to avoid leaving little empty spaces behind in RAM because if it is required to search any last character list word then it is not needed to crawl all other characters before as it was done before so it became better and optimized also in view of computer load and performance.

4.4 Current Dictionary Prediction and Suggestion

It is now made possible to show words from URDU dictionary starting from the first letter that are typed in ascending order and showed the next word as per the last typed word from the most common dictionary.

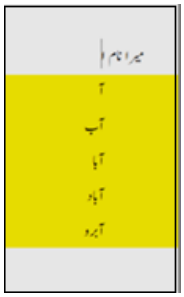


Figure 3: Current Dictionary Predict & Suggest

4.5 Current Runtime Prediction and Suggestion

It is now made possible to show words from URDU dictionary starting from the first letter that were typed in ascending order but will show the user's typed dictionary word on the top of the list and will also show the next word as per the last word typed by the user from the current runtime study from the dictionary.

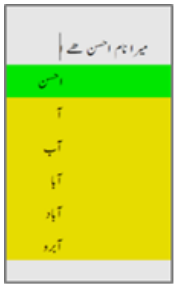


Figure 4: Current Runtime Predict & Suggest

4.6 Current Typed Text Prediction and Suggestion

It is made possible to show words from URDU dictionary starting with the first letter that were typed in ascending order and would show the user the typed dictionary word on top of the list and also show the wrong typed words in the list also and would will also show the next word as per the last typed word from the current runtime study.

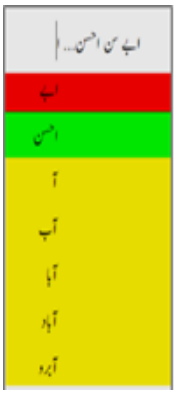


Figure 5: Current Typed Text Predict & Suggest

4.7 Next Dictionary Prediction and Suggestion

Through the study it is now made possible to show words from URDU dictionary starting with the first letter that were typed in ascending order and it would also show the next word as per the last typed word from the most common dictionary.

Figure 6: Next Dictionary Predict & Suggest

4.8 Next Runtime Prediction and Suggestion

The study made it achievable to show words from URDU dictionary starting with the first letter that were typed in ascending order but would show the typed dictionary word on the top of the list and also show the next word as per the last typed word from the current runtime study from the dictionary.

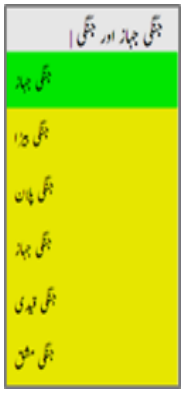


Figure 7: Next Runtime Predict & Suggest

4.9 Next Typed Text Prediction and Suggestion

The study showed words from URDU dictionary starting with the first letter that was typed in ascending order and would show the typed dictionary word on the top of the list and also show the wrong typed words in the list as well and it would also show the next word as per the last typed word from the current runtime study

Figure 8: Next Typed Text Predict & Suggest

4.10 N-gram Model

In statistical based techniques, by performing n-gram analysis, the sentence probability was to be measured. Here if the text was split in double words, it ended up in (N/2) words lists of the total (N) text but this would not be intelligent as it should be so that if there is a text "I am a student", then here as per (N/2) logic, it would get "I am", "a student" that means that when it was typed "I" then it would have got "am" as suggestion to next word and same as "a" word would get "student" as a suggestion but what about when it was typed "am" then as per rule, it should have got "a" as suggestion but (N/2) logic would not help in this phase so it was not recommended. So for taking hold on this problem,

(N-1) logic was used to cover this problem so here the text was split in double words then it ended up in (N/2) words lists of the total (N) text as it should as if there is a text "I am a student", then here as per (N-1) logic, it would get "I am", "am a", "a student" that means this would be intelligent as it should, as if there was a text "I am a student", then here as per (N-1) logic, it would get "I am", "a student" that mean when it was typed "I" then it would get "am" as a suggestion for the next word and same as "a" word will get "student" suggestion and when it was typed "am" then it would also get "a" as a suggestion as per the new rule.

4.11 Hidden Markov Model

The classification problems could be solved by utilizing the Hidden Markov Model (HMM); one of the statistical based model presented by [21] and [22]. It could be represented as the set of transition probabilities connecting the interconnected set of states. So here when there are BiGrams, the previous states from where the user has passed to make a map of the states out of a full word was watched, so later when keeping the frequencies of the transaction from the states, the next typed words is redirected as per the transaction probability secured earlier.

4.12 Searching from Main Dictionary

A list was first created to keep the default dictionary data that was good over array because it would keep the RAM compressed and clean to avoid leaving little empty spaces behind in the RAM but this data list became long that was also good but the Linear Search would go to worst case to O(n) that would take time to search at every click of the mouse. To avoid this, this concept was avoided so the logic that was the same as a HASH Table or HASH Map etc. was created. One list of dictionaries was simply divided in 40 dictionaries and assigned each dictionary to an alphabet/character of URDU that leads us to make our worst-case O(n)/40 that meant that it got 40% faster than before. Here just the desired word starting character needed to be checked and redirected the search to only that character dictionary list and whatever it would find there, it would be much faster than before. If it was required to search any last character list word, it was not required to crawl all other characters before as it was done, So here it got better and optimized also in view of computer load and performance.

4.13 Searching from Run-Time Dictionary

It is now made achievable to show words from URDU dictionary starting from the first letter that was typed in ascending order but would show the typed dictionary word on top of the list and it would also show the next word as per the last typed word from the current runtime study from the dictionary.

5. Overview of Modules

The study has designed a GUI application which contains a text fields where user would type word and application would give suggestion so that the user would be able to get access to the suggestion lists in an easy way and it also initialized all the single word dictionary and double word dictionary at the time of object creating. It was required to show the suggestion so after finding out the position, the user just went one char back to find out what user typed and then user chooses from the possibilities that either they typed an alphabet char or a non-alphabet char that would help them by taking the right decision.

5.1 Updating Run-Time Dictionaries

If there would be a non-alphabet character, the user would run the background process that would update the run time dictionary with user for the currently typed words. It was also required to make the double word dictionary at the run time but that would be a different task as normal. It was attempted to create a full probability approach to cover all the maximum probability as shared above under "Using (N-1) Logic for More Artificial Intelligence".

5.2 Half or Full Typed Words

After getting double word runtime dictionary, programmer would be able to get the user data in their program that would help them later to suggest the better and perfect. Till now there was a fully typed word and a half-typed word, it was again split in two different ways to do as per the requirements.

6. Results and Discussion

This paper presented a model which was successfully implemented using C# and tested as a standalone model. This model was based on Urdu language which contains two dictionaries called pre-build and runtime word list. Upon user typing, the model predicted new words with its current context and store into the pre-build dictionary and display the word list as a suggestion. The runtime dictionary shows those words which are nearest to the user typing and predicted from the main dictionary. User easily accessible all the words available in runtime wordlist. This model also achieved some additional feature where user easily manage each word by pressing key up and down arrow in the word list using keyboard. The user easily press enter key to select any word given in word list. The design of the model is simple and easily used by any user, programmer and, etc. We set up different parameters (words)

to validate our model as a standalone application. The predicted words were accurate and nearest to the user context. This model adds new contribution in Urdu language and software industry.

7. Application Overview

An applications was built as mentioned above. Some working screenshots are taken from it to explain it more clearly.

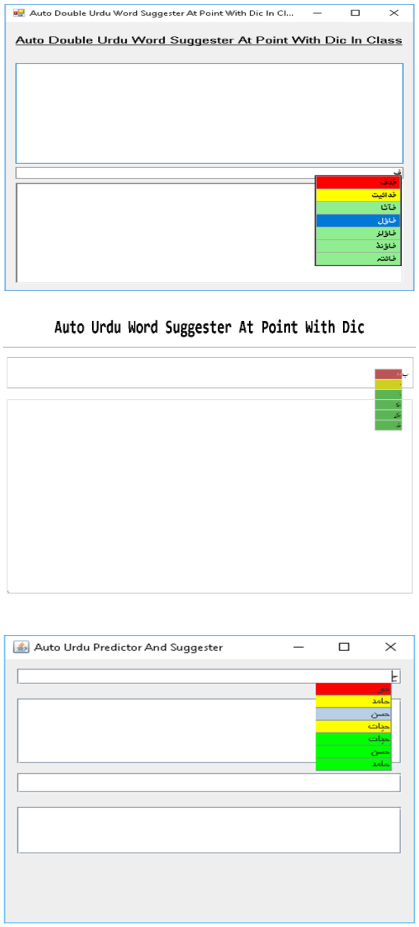


Figure 9: Application View

8. Conclusion

A pioneering research has been presented for Auto Suggestor and Predictor of word (Get Your Word Before Your Typing to Increase The Typing Speed).(N-1) logic has been used for more Artificial Intelligence, different algorithms, and searching approaches to increase the typing speed by providing better auto suggestions and predictions. Although the research and experiments did not contain a huge amount of data, the outcomes met state-of –the- art work. It has been noticed that words dictionary, quality and quantity had significant impact on predicting the list of suggestion and its precision.

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