Homeland security and personal safety are receiving significant attention worldwide, both to ensure the well being of populations and to enhance the quality of the human life. It is important to detect critical situations and recognize dangerous conditions as early as possible, to effect appropriate reactions. Natural disasters impart lessons at a very high cost of life and property. But if those lessons do not lead to learning and knowledge generation then it is a very heavy cost to bear. This lack of learning from the past hurts most at the recurrence of disasters. The earthquake in Gujarat and the subsequent chaos was an indicator of how crucial disaster planning is to manage relief and rehabilitation during disasters.

**What causes a tsunami?**

A tsunami is a large ocean wave that is caused by sudden motion on the ocean floor. This sudden motion could be an earthquake, a powerful volcanic eruption, or an underwater landslide. The impact of a large meteorite could also cause a tsunami. Tsunamis travel across the open ocean at great speeds and build into large deadly waves in the shallow water of a shoreline.
6.1 INTRODUCTION

Earthquake Causes Tsunami

Energy accumulates in the overriding plate until it exceeds the frictional forces between the two stuck plates. When this happens, the overriding plate snaps back into an unrestrained position. This sudden motion is the cause of the tsunami - because it gives an enormous shove to the overlying water. At the same time, inland areas of the overriding plate are suddenly lowered.

Tsunami Races Away From the Epicenter

The moving wave begins travelling out from where the earthquake has occurred. Some of the water travels out and across the ocean basin, and, at the same time, water rushes landward to flood the recently lowered shoreline.

Tsunamis Travel Rapidly Across Ocean Basis

Tsunamis travel swiftly across the open ocean. For example, a tsunami produced by an earthquake along the coast of Chile in 1960 traveled across the Pacific Ocean, reaching Hawaii in about 15 hours and Japan in less than 24 hours.

Disaster managers and calamity officials are in burning need of equipped tools that will afford accurate tsunami forecast as direction for speedy, significant decisions in which lives and possessions are at risk. The more apt and accurate the warnings are, the more efficient proceedings can local disaster managers can take so that many lives and more possessions are saved.
Tsunami is a series of huge waves that happens after an undersea disturbance, such as an earthquake or volcano eruption. Tsunami is from the Japanese word for harbor wave. The waves travel in all directions from the area of disturbance, much like the ripples that happen after throwing a rock. From the area where the tsunami originates, waves travel outward in all directions. Once the wave approaches the shore, it builds in height. Tsunamis can travel thousands of miles across the open ocean, where they are difficult to see, rarely reaching more than 3 feet in height. The topography of the coastline and the ocean floor will influence the size of the wave. Tsunamis often exceed 100 miles in length in the deep ocean, where they can travel as fast as 500 miles per hour, crossing the entire Pacific Ocean in less than 24 hours. As a tsunami reaches the shallow water near a coastline, its speed decreases, but as the wave compresses it may grow to a height of 7 meters to 10 meters or more. The height of a tsunami as it approaches a shoreline is referred to as its "run-up." The run-up of the 1964 tsunami that struck Alaska was as high as 27.4 meters in some places.

6.2 OVERVIEW OF TSUNAMI MONITORING

Tsunamis and the geologic events that cause them are some of the most severe natural disasters known. Tsunamis are often preceded by a rapid drop in local sea level, similar to an unusually low tide. A tsunami cannot be precisely predicted, even if the magnitude and location of an earthquake is known. Seismologists analyze each earthquake and based on many factors may or may not issue a tsunami warning. However, there are some warning signs of an impending tsunami and automated systems can provide warnings immediately after an earthquake in time to save lives. One of the most successful systems uses bottom pressure sensors that are attached to buoys. The sensors constantly monitor the pressure of the overlying water column. A sufficiently large earthquake magnitude and other information trigger a
tsunami warning. While the subduction zones around the Pacific are seismically active, not all earthquakes generate tsunami. Computers assist in analyzing the tsunami risk of every earthquake.

Tsunami researchers might soon be able to generate near real-time tsunami simulations before the deadly waves reach vulnerable coastal regions. The combination of pre-computed scenarios of tsunamis generated by underwater quakes and broadband seismographic data could lead to simulations that show which coastal areas are threatened by inundation in time to give a warning. The technology can save many lives when tsunamis strike again, but can also help experts in determining which coastal areas are unsafe for habitation. Real-time tsunami simulations require fast and accurate seismic data, but the National Oceanic and Atmospheric Administration (NOAA) is building a network of broadband seismic monitoring stations around the world that offer real-time information about ocean basin earthquakes. This is dealt by Krikke. (2005). The Pacific warning system ties together two elements: a surveillance network of seismic sensors, tide gauges, and satellites - and detailed maps of the ocean floor. (Ross 2005). The 19 articles mentioned in the work of Chen et al 2007 focus on remote sensing for major disaster prevention, monitoring, and assessment. Topics include earthquakes and landslides, tsunami, hurricanes and typhoons, floods and fires, as well as papers with a broader focus, highlighting innovative tools and procedures to exploit Earth observation data.

Underwater Area Sensor Nodes (UASN) dealt by Erol-Kantarci, et al 2010 with sensing and communication capabilities form the underwater acoustic sensor network. Localizing the underwater sensor nodes is one of the fundamental tasks for UASNs where the location information can be used in data tagging, routing, and node tracking.
The International Federation of Digital Seismographic Networks (FDSN) proposed by Suarez et al 2008 is a non-governmental organization formed by institutions dedicated to seismological research and seismic monitoring. The FDSN is a successful complement to the International Seismological Centre (ISC) in pursuing a more than a century old tradition of global seismic data exchange. The main goal of the FDSN is the production and dissemination of seismic waveform data from high fidelity seismic observatories. The federation is formed by 65 organizations from 52 countries that contribute data to three main data centers in the United States, Europe, and Japan. The fault that ruptured on 25.10.2010 on Sumatra island's coast caused" a white wall of water” that washed away 500 people from the seashore. This fault caused the 2004 quake and monster Indian Ocean tsunami that killed 2, 30, 000 people in a dozen countries. Tsunamis are 2 percent as likely in the Indian Ocean, and the nations there will find it harder to maintain their resolve.

In this work, a texture analysis based tsunami prevention and monitoring model is proposed. The texture analysis is used for various image processing applications like browsing and retrieval of image data and dealt by Manjunath 1996. The detailed review of texture analysis is available in Ojala et al 1999. The texture analysis uses fourier transform as given by Matsuyama.et al 1983, auto regression model as proposed by Mao et al. 1992, wavelet transform as dealt by Zhi-Zhong Wang, and Jun-Hai Yong, 2008 for feasibility. Detailed implementation of ANN is explained in the work proposed by Chandra Mohan. and Baskaran 2011 which represents ANN in the implementation of predictive routing.

Texture analysis is one of the fundamental aspects of human vision, in which, surfaces and objects are identified and classified. The applications of texture are analysed to derive a common, result oriented and robust
quantitative description of textures. In texture analysis, various mathematical operations can be used to alter, compare and transform textures. Most available texture analysis algorithms involve extracting texture features and deriving an image coding scheme for presenting selected features. Four major application domains related to texture analysis are texture classification, texture segmentation, shape from texture and texture synthesis.

6.3 MATERIALS AND METHODS

Recent advances in digital imaging technology have greatly enhanced the interpretation of changes in textures from the 2-dimensional real-time images. This has become realistic due to the existence of the computer aided defect detection tool. A computer aided defect detection tool (CADD) generally possesses components like pre-processing, image enhancement, identification/selection of region of interest, extraction of textural features and finally an efficient classification system. This work enumerates on development of CADD tool for classification and analysis of surface of sea. Characterization of surface through texture analysis leads to the detection of abnormality which is not feasible through qualitative visual inspection by the technician. The proposed work involves an optimal block analysis (64x64) of the sea surface image of actual size 256x256 by incorporating Gabor wavelet transform which does the texture classification through automated mode. Statistical features such as mean, standard deviation are estimated after this pre-processing mode. A Feed forward neural network with back propagation algorithm is applied for classifying the texture yielding classification accuracy of 92%. Further multi-classification are also performed which yields an overall classification accuracy of 94.5%. The system has to be tested with several images for further validation. The main objectives of this proposed works are as follows:
1. To acquire the real-time image for identifying the changes in texture or abnormality.

2. To apply suitable pre-processing technique for filtering the noise if present and to enhance the image for extracting the possible features.

3. To classify the normal and abnormal image using suitable classifier.

The current work is to determine the minimal set of features required to uniquely characterize each texture class, in image processing so that it results in less computational complexity and time saving. The approach is divided into three steps:

![Figure 6.1 Block diagram](image-url)

Figure 6.1 Block diagram
1) **Defining the Region of Interest (ROI)**

Defining the ROI is one of the most important steps in characterizing the texture since it is the basis for all the following steps. In order to accurately identify and quantify regions, they should be as free as possible from the effects of the imaging system.

2) **Quantifying the Features of ROI**

The second step in texture classification, is quantifying features of the region studied. Features used to characterize region include grayscale and Texture analysis is based on grayscale statistics.

3) **Making Decisions about the Nature of ROI**

Classifying objects or regions is based on neural network analysis. Samples from images are taken, grouped and numbered according to each case. The following image features are extracted from each image:

- Mean graylevel
- Variance of graylevel

The proposed work involves an optimal block analysis (64x64) of the image of actual size 256x256 by incorporating Gabor wavelet transform which does the texture classification through automated mode, the block diagram is shown in Figure 6.1.

Statistical features such as mean and variance are estimated using equations 1 and 2 given below. The *mean* of a data set is simply the arithmetic average of the values in the set, obtained by summing the values and dividing by the number of values, which is given in the equation (1).
\[ g_{\text{ave}} = \left( \frac{1}{N} \right) \sum_{i,j \in R} g(i,j) \] \hspace{1cm} (6.1)

Where \( g_{\text{ave}} \) is mean, \( N \) represents the total number of data, \( R \) represents Region of interest and the \( g(i,j) \) are grey level of pixels. The \textit{variance} of a data set is the arithmetic average of the squared differences between the values and the mean, which is given in the equation (2).

\[ V_g = \left( \frac{1}{N} \right) \sum_{i,j \in R} (g(i,j) - g_{\text{ave}})^2 \] \hspace{1cm} (6.2)

A feed forward neural network with back propagation algorithm is applied for classifying the images yielding classification accuracy of 92%. Further multi-classification can also be performed which yields an overall classification accuracy of 95%. The details of neural networks and training are shown in Figures 3.3 to Figure 3.7 and the equations are shown from 3.3 to 3.20. The system has been tested with several images for validation. Automated analysis plays a vital role in classification of images due to its accuracy and efficiency. It offers a powerful tool for enhancing images. It is easy to point out abnormality very accurately due to computer visualization. Transform methods of texture analysis used in this system is Gabor Wavelet. The gabor wavelet is a new approach implemented in this tool for the extraction of textural features and the Gabor Features are extracted from real-time images. As the gabor wavelet is proposed in the proposed work, noise are reduced, redundancy is minimal, classification error are reduced.

A 2D Gabor function \( g(x,y) \) and its Fourier transform \( G(u,v) \) can be written as equation 6.3:
\[
g(x, y) = \left( \frac{1}{2\pi \sigma_x \sigma_y} \right) \exp \left\{-\frac{1}{2} \left( \frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2} \right) + 2\pi jWx \right\}
\]

\[
G(u, v) = \exp \left\{-\frac{1}{2} \left( \frac{u - W)^2}{\sigma_u^2} + \frac{v^2}{\sigma_v^2} \right) \right\}
\]

where \(\sigma_u = 1/2\pi \sigma_x\), and \(\sigma_v = 1/2\pi \sigma_y\). Gabor functions form a complete but non-orthogonal basis set. Expanding a signal using this basis provides a localized frequency description. A class of self-similar functions, referred to as Gabor wavelets, is now considered. Let \(g(x, y)\) be the mother Gabor wavelet, then this self-similar filter dictionary can be obtained by appropriate dilations and rotations of \(g(x, y)\) through the generating function:

\[
g_{m,n}(x,y) = a^{-m}g(x',y'), a > 1, m, n = \text{integer}
\]

\[
x' = a^{-m}(x\cos\theta + y\sin\theta), \text{ and } y' = a^{-m}(-x\sin\theta + y\cos\theta)
\]

where \(\theta = \frac{n\pi}{K}\) and \(K\) is the total number of orientations. The scale factor \(a^{-m}\) is meant to ensure that the energy is independent of \(m\).

### 6.4 RESULTS

Mean and variance were computed for the widely-used texture images from Brodatz texture album and the results are shown in Figures 6.2 to 6.5. Each class of texture has a definite value of these parameters and thus textures can be discriminated effectively by this method. The proposed method has been tested for real-time conditions of sea also. Experiments conducted on images such as rock, beach-sand, mixture of soil and sea water, stagnant water, well water, lake water, river water, water flowing down from water falls at a very high speed, surface of sea before and after the occurrence of tsunami and so on clearly reveal that this proposed method can be used as a tool for detecting the changes on the surface of sea. Whenever tsunami waves reach an island or seashore it can be detected and
then other islands or seashores in close proximity may be issued warnings as early as possible so that disasters can be prevented.

Figure 6.2 Input image 1 for texture analysis

Figure 6.3 Variation in features of Input image 1
Figure 6.4 Input image 2 for texture analysis

Figure 6.5 Variation in features of Input image 2
6.5 DISCUSSION

The theory and experiments have demonstrated that the surface of the sea can be effectively monitored by using texture analysis and abnormalities can be found. A Computer aided defect detection tool is developed in order to detect and classify the surface of sea. The system is an automatic system which can be used not only by the technician but also persons who are not related to this field. The wavelet transform system produces better results in extraction of features. The classification accuracy from binary and multiple classifiers are about 94.5%. Surface images of sea like water, water mixed with sand and abnormal effects due to Tsunami are classified. The future enhancements can be done to increase the accuracy of the system and including more feature extraction methods. It can be extended to classify images using various inputs of images of different sizes.

6.6 CONCLUSION

The performance of proposed texture analysis is proved as optimal. The results of the proposed work show optimality in all aspects, and offers effective prevention of loss in tsunami like sea shore problems. Texture features are calculated and by using neural networks, the sea surfaces are analyzed for various conditions. The performance of the system has been tested and an efficiency of 95% has been achieved. Really, this Tsunami Alarm Model will be a boon to mankind in the days to come, since this automated computer vision system can analyze real-time multispectral satellite images, issue warning signals and can save the society from disasters.