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Flood Estimation from Water Discharge Using Regression Analysis

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Abstract

Flood is the maximum flow which may be run off a catchment area during a period of exceptional rainfall. The flood estimate models predicts the risk reduction with minimization of the loss of human life, and decrease of the property impairment linked with Flood. In this paper the flood is estimated by calculating image processing parameters on water discharge from canal. The estimation of flood is analysed with 'Logistic Regression', a machine learning algorithm and compared with existing state-of-art methods. This is then used to train and test the model. The work shown in this paper is performed on the Khadakwasala canal in Pune.

Keywords— *Flood, Flood estimation, Discharge, Image processing, Train-Test model, Machine Learning.*

I. INTRODUCTION

Flood estimation basically needs calculation of Discharge in a canal or river. During monsoon months, large quantities of water flow as runoff. When water fills a river beyond its capacity, water flows out of river to its neighbouring land, this may cause flood .This paper aims at the proposed system to estimate Flood. The output of the study will be more precise than the existing measurement systems which use contact type sensors to measure velocity and more complex Machine Learning (ML) algorithms. Image based technique is an emerging and new measurement technique that is changing the way of measuring surface water resources. There are few data-driven approaches of prediction integrate the measured climate guides with hydro-meteorological parameters to offer better understanding. This method is reckless, mechanized and high-tech.

II. BASIC PRINCIPLE

A. Discharge calculation:

The inexpensive and laid-back way to control water surface velocity is to simply float roughly down the stream and see how fast it drives. Here, basic principle is the water surface velocity measured in the intermediate of the canal. The video of flow is taken and the measure of flow is estimated from the pair of successive frames. The frames are converted into gray scale images using RGB to gray scale conversion [1]. Canny edge detection system is functional to detect object in the frames, and finally Euclidean distance is calculated to calculate velocity. The velocity values are then multiplied with the Area of the canal to obtain Discharge. The obtained Discharge value is then used to estimate Flood.

B. Flood Estimation:

Machine learning (ML) methods provides better reliability and affordable resolutions. Due to the better productivity and potential of ML, its acceptance vividly increased between hydrologists. The Proposed architecture mainly focuses on "Logistic Regression" method which handles a large

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number of dataset having both flood and non-flood conditions [2][3]. This method is effectively used when we want output in Binary form, that is, is it a Flood condition or not.

Figure 1 illustrates the Block diagram of working of the proposed methodology:

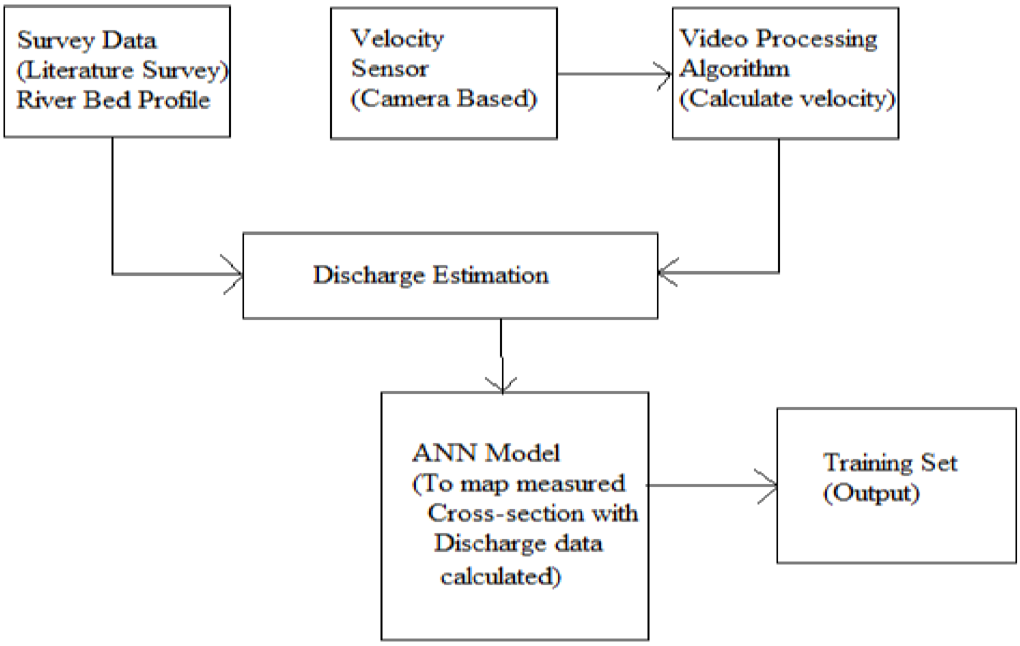

Figure [1]: Block Diagram

III. Discharge Calculation

A. Float

For measurement, object detection is very important. The flowing object must be lighter than the density of flowing water, and should flow with the water. The object needs to be inexpensive and environmentally friendly.

B. Video Recorder

The video of the flow of the object in water surface is recorded using a small webcam camera of resolution 2592x1944. It has 30fps (Frames per Second) and 720p. The function, size, price, and power dissipation and also the performance parameters are better than other digital cameras such as Sony, Samsung. This camera is small in size and has better performance.

C. Discharge Calculation

- The captured video is transformed into grey scale using RGB to grey scale converter as described in figure 2. Then Gaussian filter is applied to remove noise and Edges are detected[4] as shown in figure 3 and 4:

Figure [2]: Original Captured Frame

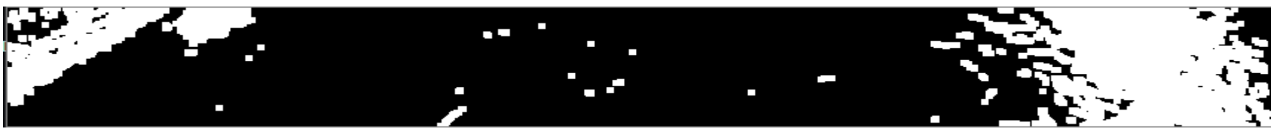

Figure [3]: RGB to Grey Converted Frame

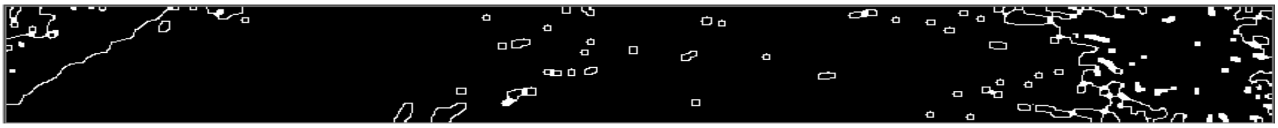

Figure [4]: Edges Detected Frame

- Then read the two consecutive frames from the took image. First split each larger image into small interrogation areas (area A, area B) with the same size which be subject to on flow velocity and time interval Δt. In practical for a window size of length k, (k/3) is an adequate limit to estimate the movement vector.

- The distance amongst any two points in real line. It is measured as absolute value of the numerical difference of their coordinates. It derives formula to recognize the name of a point with its Cartesian coordinate. In the Euclidean plane, if **p** = (p_1, p_2) and **q** = (q_1, q_2) then the distance is given by eq.1:-

$$D\,(p, q) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2} \qquad [1]$$

- Compute the Euclidean distance between the middle points of the objects.
- Then use formula Eq.2:

$$\text{Speed} = \frac{Distance}{Time} \qquad [2]$$

This gives velocity

- Calculate Discharge using Eq.3:

$$\text{Discharge} = \text{Area} * \text{Velocity} \qquad [3]$$

- Print Discharge value in meter per second(m/s).

IV. Flood Estimation

The Proposed architecture mainly focuses on “Logistic Regression” method which handles a large number of dataset having both flood and non-flood conditions. The velocity of water along with the dataset used pays to the approximation of the flood. The steps involved in this algorithm are given as below:

A. *Preprocessing*

For further processing, it is required to deploy two steps:

1. Discharge Calculation
   The surface water velocity is Calculated using image processing algorithms the discharge is calculated using equation 3.

2. Dataset Creation
   A dataset is created using past years data using different parameters like temperature, Rainfall, Humidity, Wind speed and the Discharge calculated using image processing algorithm. These values are collected from Indian Metrological Department (IMD) site which provides Day-to-Day weather report. The collected Day-to-Day weather report is then updated in an Excel sheet with required parameters. For the proposed methodology at most 336 days data are collected.

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B. *Estimation of Flood*

For the estimation of flood "Logistic Regression" algorithm is used. This algorithm is one of the most used machine learning (ML) algorithms for Binary classification.

The model is first Trained and then Tested using 3:1 ratio. 75% of the dataset is used for Training the model and 25% of the dataset is used for Testing the model.

According to [1][2], the maximum and minimum threshold is calculated with results. By constant trial and error, then it classified as the flood degree in high and low within these edge values[2]. The detailed analysis of the performance of the proposed algorithm is analysed and accuracy is estimated. Figure 5 shows the Flowchart of Flood estimation steps and working of algorithm:

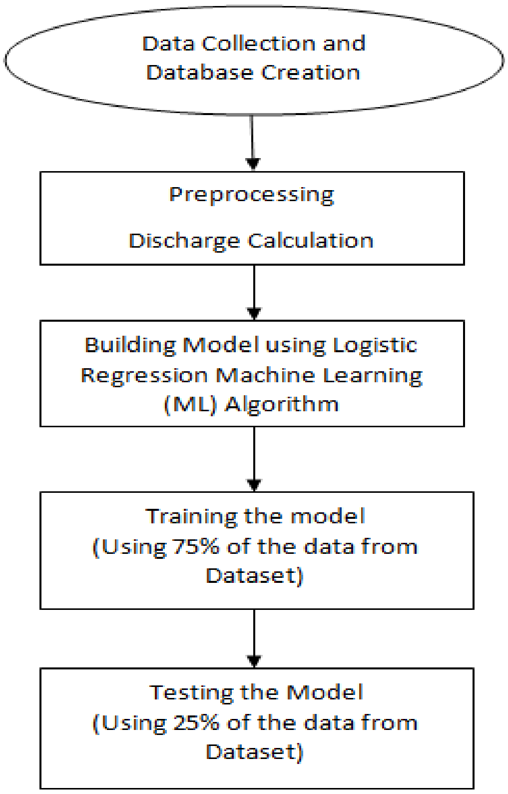

Figure [5]: Flowchart of Machine Learning (ML) model

V. RESULTS

The working model is implemented on the real-time obtained dataset and the results are calculated with different datasets obtained at Khadakwasla Dam ,Pune.

In the proposed algorithm various major computations factors contributing to the final module of estimation of flood like Average rainfall, wind speed and Temperature is used.

A confusion matrix is established with this classification formulation which is used to calculate the efficiency with accuracy of the proposed method. There are 68 flood data out of which 65 are correctly classified into flood category and 3 is misclassifies. Whereas there are 32 non flood data and 24 of them are correctly classified. Rest of them are misclassified as flood condition. The obtained Confusion matrix is as shown in table 1:

TABLE I
CONFUSION MATRIX

n = 100	Predicted: Yes	Predicted: No
Actual: Yes	TP = 65	FN = 3
Actual: No	FP = 8	TN = 24

Here: (FP) False Positive , (TP) True Positive, (FN) False Negative and (TN) True Negative

The accuracy with proposed algorithm is 0.89. To increase the accuracy more number of parameters can be considered. The more the accuracy the more reliable is the model. With greater accuracy, the estimation is accurate.

The trained model is then used to plot a graph to show Flood and non-Flood conditions as shown in figure 6:

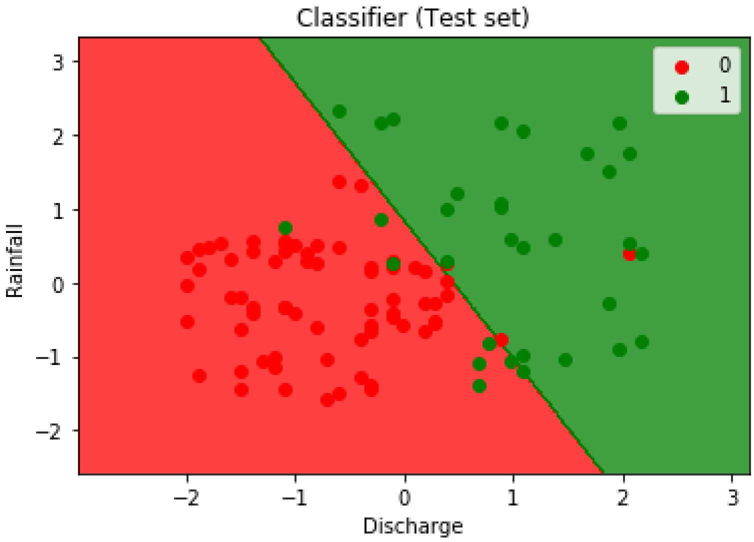

Figure [6]: Graph of Discharge vs. Rainfall

VI. Conclusions

The Flood is estimated using the surface velocity and the dataset. The results calculated from this methodology are useful for flood prone areas like, areas near a dam or canal and river side. The velocity measurement of surface water using image-based technique is a reliable, easy, cheapest measurement approach. The model is trained using previous year's data having both flood and non-flood conditions. The result has been achieved with an accuracy of 89%, which makes the model more reliable. This method aims at flood detection in a very reliable way without harming the environment. Considering limitations of existing dataset, future scope is to extend our work in view of additional features such as wind speed, velocity at different points in a canal relative to area of canal and estimate flood so that the accuracy is increased.

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