Group 5: Flood Monitoring System

Sreeram P (CEC15CS055)
Stebin Joseph (CEC15CS058)
Shelna Sebastian (CEC15CS049)
Ameta Joby (CEC15CS010)

College of Engineering Cherthala

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Overview

Introduction

- Flood is regular natural disaster in our country which happens nearly every year during the monsoon season.
- During flood, it is important to have efficient flood response operation system to manage all activities among different related agencies.
- Earlier, Ultrasonic sensing techniques have become mature and are widely used in the various fields of engineering and basic science.
- Beginning in July 2018, severe floods affected the south Indian state of Kerala, due to unusually high rainfall during the monsoon season.
- This flood monitoring system has been designed to help local authorities to provide a more systematic solution.

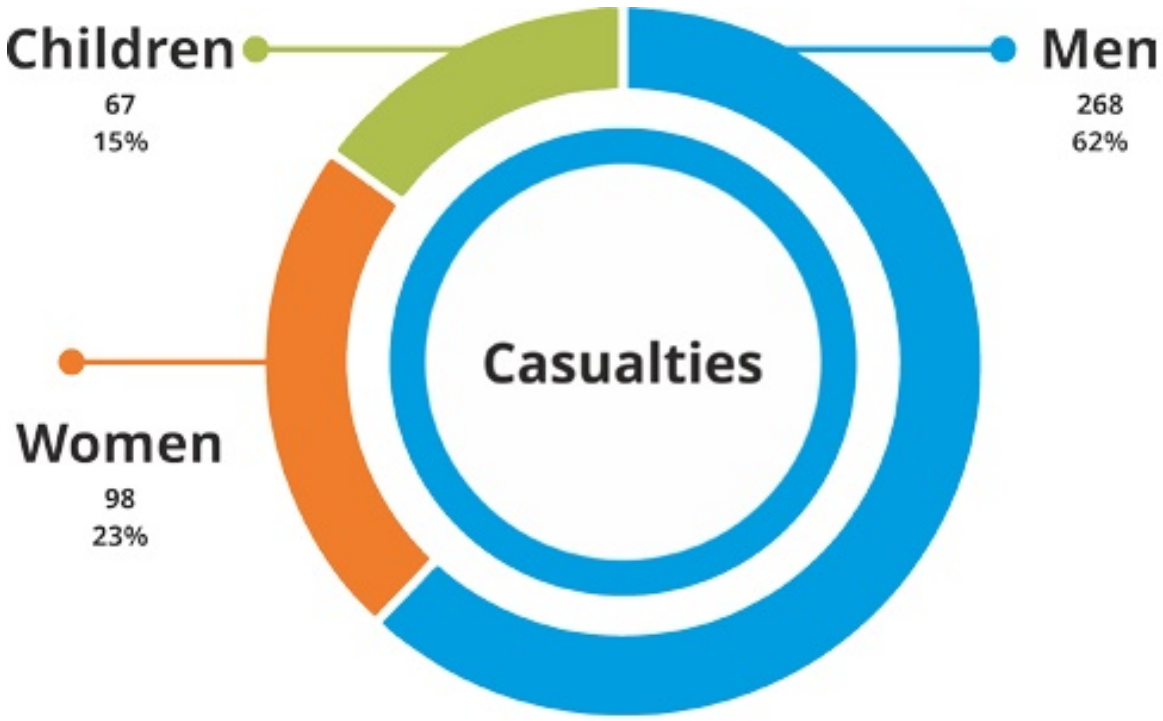


Figure: Flood 2018 (Kerala) : Statistics

- Detecting floods in real-time and taking rapid actions are of utmost importance to save human lives, loss of infrastructures, and personal properties.
- The main objectives of our project is to serve as an information channel for flooding between the involved authorities to enhance their responsibilities and collaboration
- Here we develop a low-cost, low-power system using a Raspberry Pi camera to detect the rising waterlevel.

- We employ image processing, edge detection and prediction method to detect the rising water level and predict the time of impact.
- In the hardware section we use Raspberry-Pi, which has main tasks as an image processor . In the software section, OpenCV library will be used for Image Processing.
- Some method which we use in the project are Region of Interest, Edge detection and so on.
- By using these methods, the system can read and monitor the water level.

Literature Survey

LITERATURE SURVEY				
Ref Paper	Technology	Advantages	Disadvantages	Keywords
Flood monitoring and warning system	GPRS, Virtual-COM, WAP, Wireless Sensor	Real-time data, Wireless sensors network which enables GPRS comminication	GPRS may be unstable, Networking coverage area cannot be implemented	Sensors, monitoring, Flood control.
Flood Monitoring using computer vision	Sensors, GPRS	Water depth estimation, Geo-tagged images	Detection algorithm may fail, Doesn't send warning messages	Geo-tag.

Urban Flood Monitoring and analysis	Participatory sensing techniques	Estimate flood level, Immediate result, Observations are recorded	No warning system, No Accuracy	Feature matching, Flood monitoring, Participatory sensing.
Development of a Remote Station for Real-time Monitoring of Urban Flooding	GPRS, Web-based tool, Pressure Sensor	Sensing differences are small enough to issue warning	No accuracy, No reliability	Urban flooding, Flood monitoring, Image processing.

Problem Statement

- Every year, the flood destroys lives and valuable resources throughout the world.
- The aim of our project is to develop a flash flood system to monitor the water level rise in rivers which are prone to severe flood, since the existing systems are not much accurate.

Proposed system

Flood monitoring system using Computer Vision.

- Develop a system for monitoring water level to be employed in monitoring flood. The change in the water level during the flood will be accurately monitored and recorded for further analysis.
- The system can be used to predict the level of water in an area during flood at a particular time.

System Design

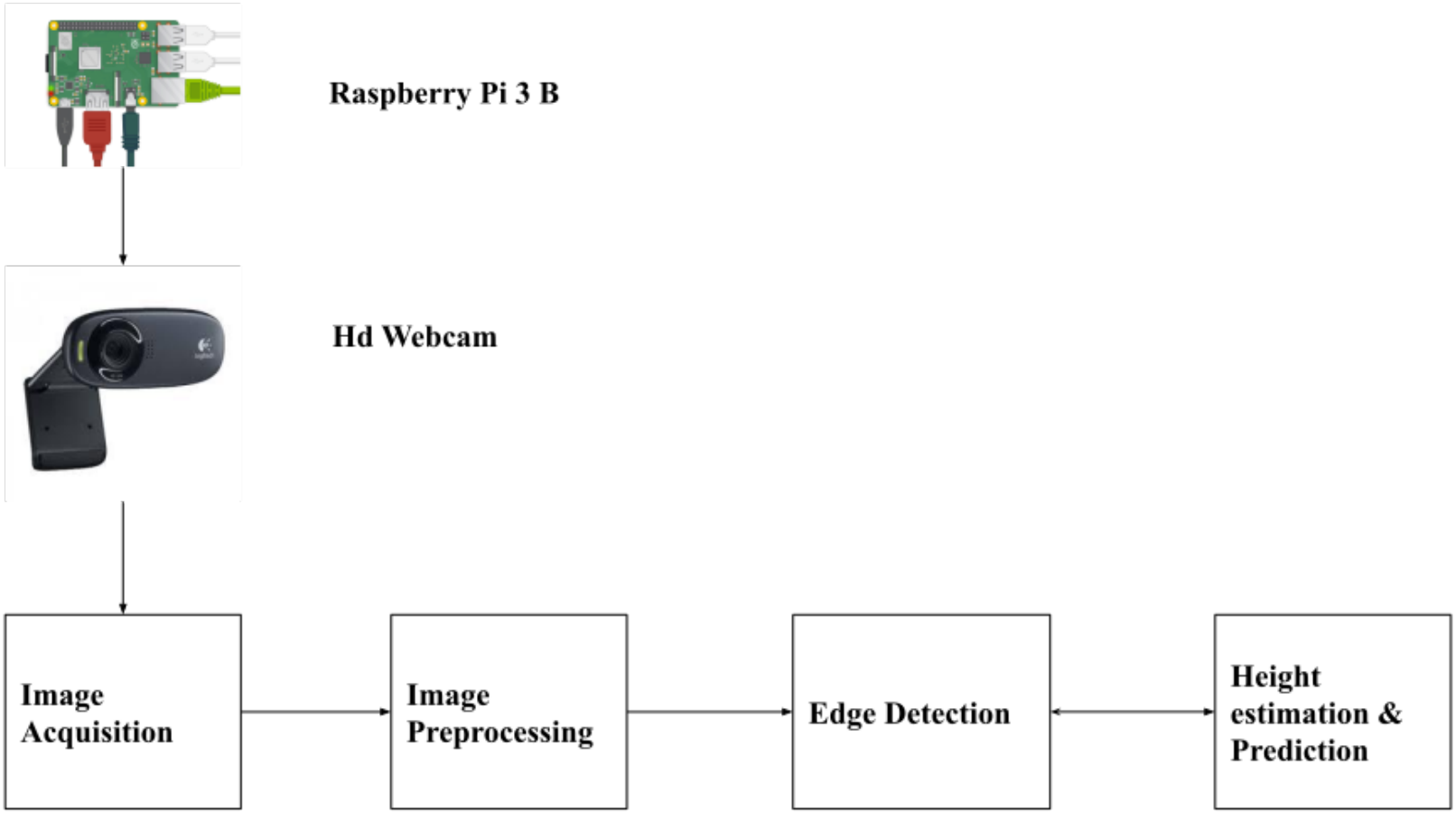


Figure: Outline of the proposed system

System Design

- We develop a low-cost, low-power system using a Raspberry Pi camera to detect the rising water level.
- It employ image processing, edge detection and prediction method to detect the rising water level and predict the time of impact.
- In the hardware section we use Raspberry-Pi, which has main tasks as an image processor and do an update to the system.
- OpenCV library is used as Image Processing Software.
- Some method which we use in the project are Region of Interest, Edge detection, Grayscale etc.
- By using these methods, the system can read and monitor the water level during the flood and can be used to predict the level of water in an area at a particular time.

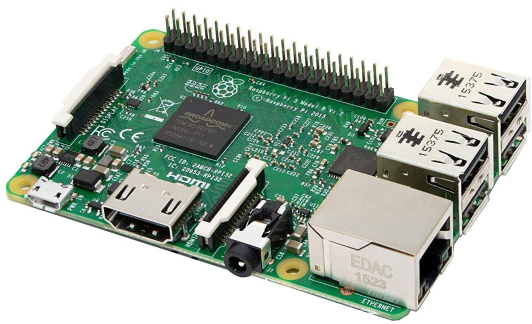
MODULES

1. IMAGE ACQUISITION
2. IMAGE PREPROCESSING
3. EDGE DETECTION
4. HOUGHLINE TRANSFORM
5. HEIGHT ESTIMATION PREDICTION

1.IMAGE ACQUISITION

- It is defined as the action of retrieving an image from some source, usually a hardware-based source for processing.
- It is the first step in the work flow sequence because, without an image, no processing is possible.
- The image that is acquired is completely unprocessed.
- Here the captured time-variant images of rising/receding water level in the stream is produced.
- There will be a camera connected to a Raspberry Pi which takes real time video of the flowing river, which can be used for monitoring.

- The most crucial task for our work is being able to capture time-variant images of rising/receding water level in the stream.
- As our system is to be deployed in the wild, so we needed a portable image capturing unit.
- Therefore, it is encased raspberry pi micro-computer and a camera into the watertight enclosure with its battery supply.



2.IMAGE PREPROCESSING

- The aim of pre processing is an improvement of the image data that suppresses unwilling distortions.
- This include Grayscale conversion of input image and ROI trimming .
  Grayscale conversion
- The images are represented using colors in BGR (Blue, Green, Red) format using the imaging software.There are other color models facilitated by different image propcessing softwares.
- Images are converted to the models that are found to be suitable for the application. Different color models enhance the required features required for the image analysis.
- Gray scale color space codes information relates to the intensity variation in the image.

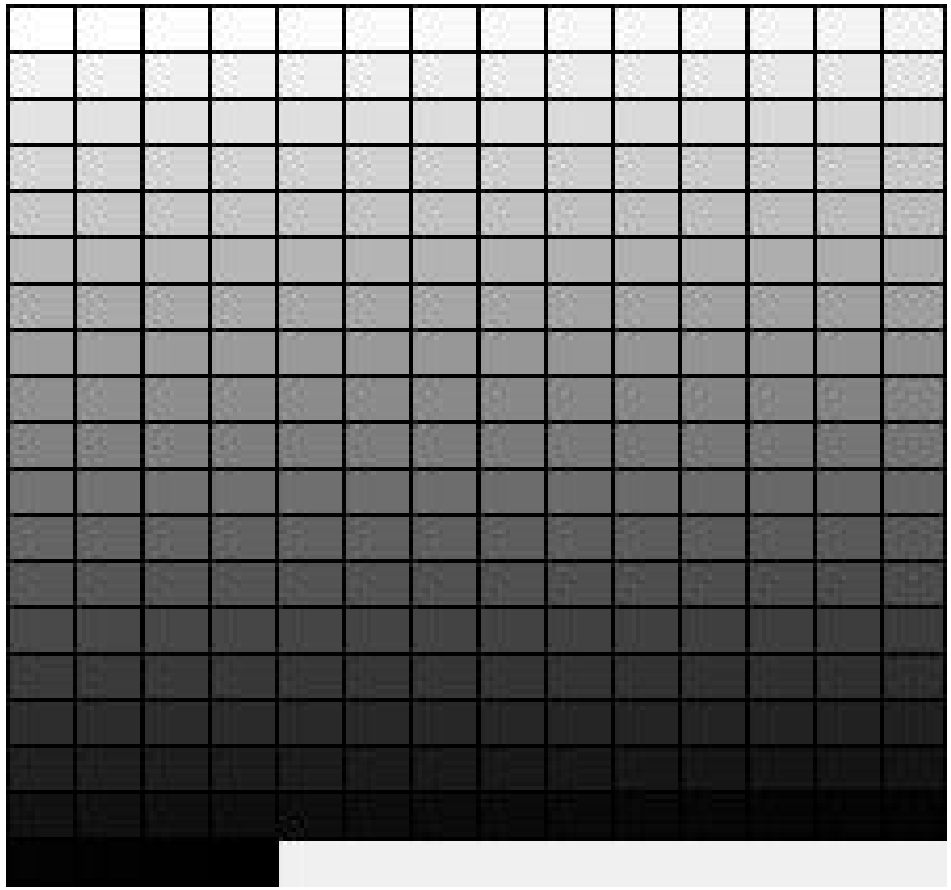


Figure: Grayscale palette

Region of interest

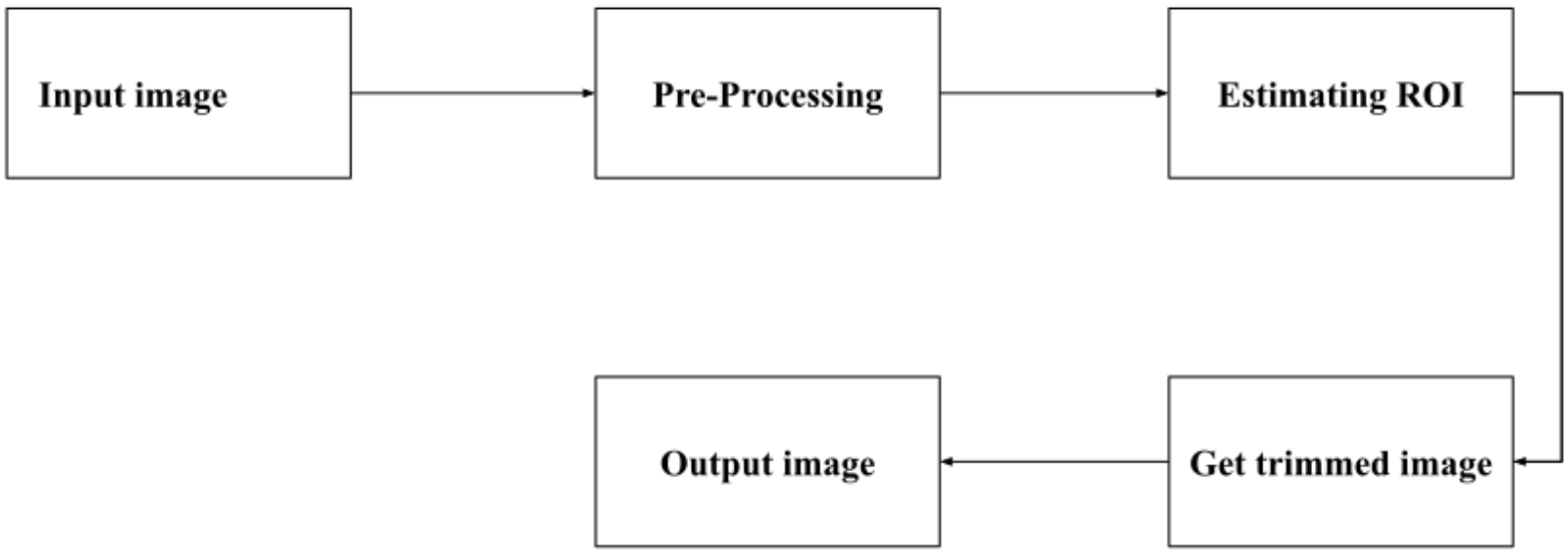


Figure: ROI Block diagram

- A region of interest (ROI) is a subset of an image identified for a particular purpose.
- The ROI is defined by given boundaries on the image.
- We have the option of using a function **selectROI** that is natively part of OpenCV.
- It allows you to select a rectangle in an image, crop the rectangular region and finally display the cropped image.
- A ROI allows us to operate on a rectangular subset of the image.
- It improves accuracy and performance (because we search for a small area).

3.EDGE DETECTION

- For the purpose of the edge detection canny edge algorithm is chosen.
- The canny edge detector describes the isolation of the most dominant intensity differences in an image where strongly emphasized and thinned out edges will finally be delivered in the end of the process.
- Canny edge detection is an image processing method used to detect edges in an image while suppressing noise.

Canny Edge Algorithm

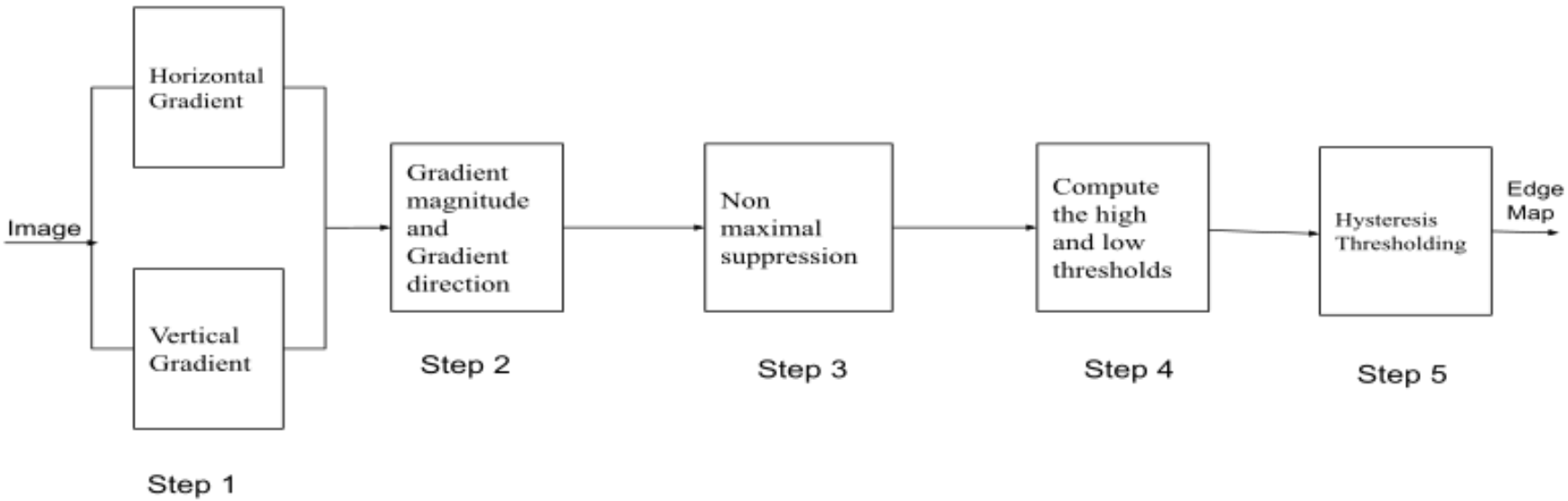


Figure: Block diagram of canny edge detection

- The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images.
- Canny edge detection is a technique to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed.
- It has been widely applied in various computer vision systems. Canny has found that the requirements for the application of edge detection on diverse vision systems are relatively similar.
- Thus, an edge detection solution to address these requirements can be implemented in a wide range of situations.

- The general criteria for edge detection include:
  1. Detection of edge with low error rate, which means that the detection should accurately catch as many edges shown in the image as possible
  2. The edge point detected from the operator should accurately localize on the center of the edge.
  3. A given edge in the image should only be marked once, and where possible, image noise should not create false edges.

- The Process of Canny edge detection algorithm can be broken down to 5 different steps:

1. Apply Gaussian filter to smooth the image in order to remove the noise
2. Find the intensity gradients of the image
3. Apply non-maximum suppression to get rid of spurious response to edge detection
4. Apply double threshold to determine potential edges
5. Track edge by hysteresis: Finalize the detection of edges by suppressing all the other edges that are weak and not connected to strong edges.

- The Canny algorithm contains a number of adjustable parameters, which can affect the computation time and effectiveness of the algorithm.
  1. **The size of the Gaussian filter:** The smoothing filter used in the first stage directly affects the results of the Canny algorithm.
     - Smaller filters cause less blurring, and allow detection of small, sharp lines.
     - A larger filter causes more blurring, smearing out the value of a given pixel over a larger area of the image.

1. **Thresholds:** The use of two thresholds with hysteresis allows more flexibility than in a single-threshold approach, but general problems of thresholding approaches still apply.
    - A threshold set too high can miss important information.
    - On the other hand, a threshold set too low will falsely identify irrelevant information (such as noise) as important.

4.HOUGH LINE TRANSFORM

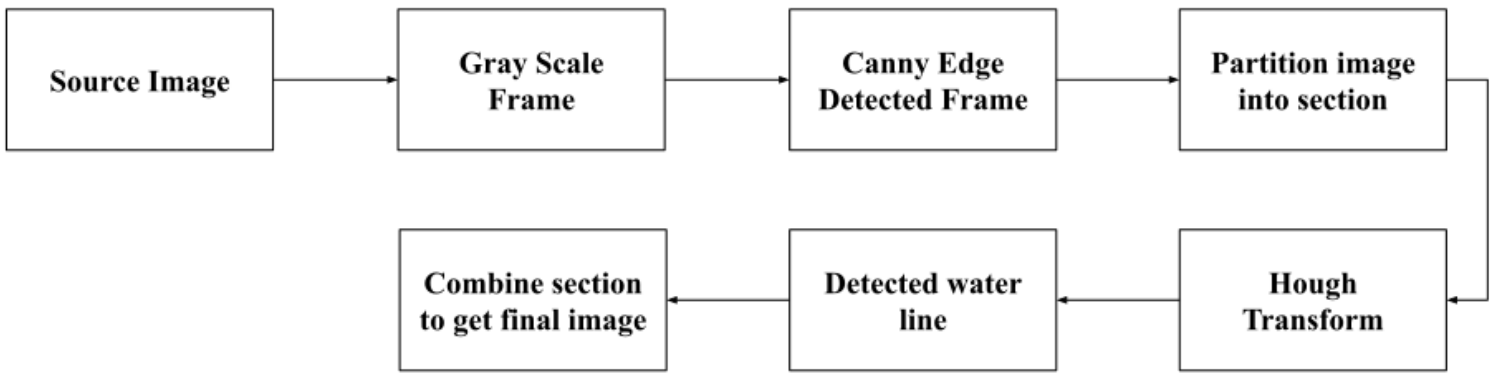


Figure: Block Diagram of Houghline Tranform

- Hough Transform is a popular technique to detect any shape, if you can represent that shape in mathematical form. It can detect the shape even if it is broken or distorted a little bit.
- A line can be represented as y=mx+c or in parametric form as, $\rho =$ xcosθ + ysinθ where, ρ is the perpendicular distance from origin to the line, and θ is the angle formed by this perpendicular line and horizontal axis measured in counter-clockwise
- So if line is passing below the origin, it will have a positive rho and angle less than 180.
- If it is going above the origin, instead of taking angle greater than 180, angle is taken less than 180, and rho is taken negative.
- Any vertical line will have 0 degree and horizontal lines will have 90 degree.

- In the hough transform, even for a line with two arguments, it takes a lot of computation. Probabilistic Hough Transform is an optimization of Hough Transform.
- It doesnt take all the points into consideration, instead take only a random subset of points and that is sufficient for line detection.
- Just we have to decrease the threshold.
- The function used is cv2.HoughLinesP().
- It has two new arguments:
- **minLineLength** - Minimum length of line. Line segments shorter than this are rejected.
- **maxLineGap** - Maximum allowed gap between line segments to treat them as single line.

4.HEIGHT ESTIMATION AND PREDICTION

- Height of the water level can be analyzed using the HoughLine Transform. Linear Regression is a machine learning algorithm based on supervised learning.
- It performs the task to predict a dependent variable value (y) based on a given independent variable (x).
- So, this regression technique finds out a linear relationship between x (input) and y(output), ie, we can plot a graph on the basis of the input and output.
- In simple linear regression, we predict scores on one variable from the scores on a second variable. The variable we are predicting is called the criterion variable and is referred to as Y.

- The variable we are basing our predictions on is called the predictor variable and is referred to as X.
- When there is only one predictor variable, the prediction method is called simple regression.
- Linear regression consists of finding the best-fitting straight line through the points. The best-fitting line is called a regression line. Using regression to make predictions doesnt necessarily involve predicting the future.
- Instead, you predict the mean of the dependent variable given specific values of the dependent variable(s). For our example, well use one independent variable to predict the dependent variable.

- The x(independent variable) and y(dependent variable) coordinates are height and time respectively. According to the changes in the coordinates different points are plotted on the graph.
- From this,the best among them are joined together to form a straight line. So, formed is the predicted graph.
- In all cases, a function of the independent variables called the regression function is to be estimated. In regression analysis, it is also of interest to characterize the variation of the dependent variable around the prediction of the regression function using a probability distribution.
- Regression analysis is widely used for prediction and forecasting, where its use has substantial overlap with the field of machine learning.

IMAGE ACQUISITION

- First the video recording starts using the HDWeb cam which is connected to the raspberry pi 3

Figure: Original Frame

IMAGE PRE-PROCESSING

1. **REGION OF INTEREST:**
   - Here it is manually selecting the area of interest using the ROI trimming methods.
   - Now we drag around the area of interest and the area is selected.
   - This crops the image according to the four corners we selected.

Output:

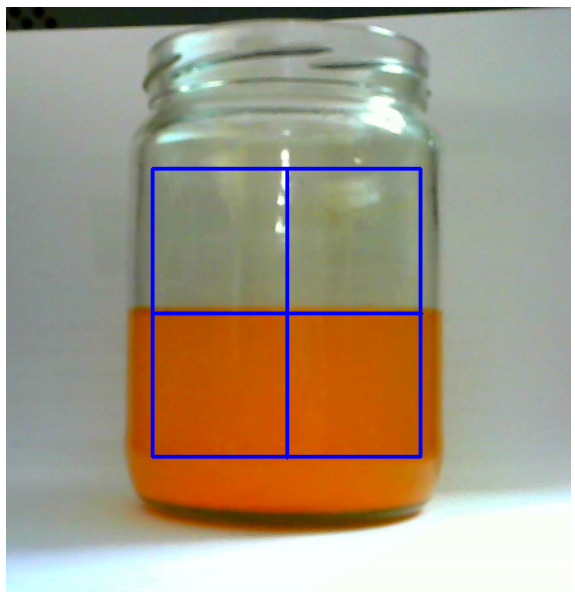


Figure: Roi Trimming

EDGE DETECTION

- Here it uses the trimmed image for edge detection.
- The edge detecton algorithm find wide range of edges.
- This smooths the image inorder to remove the noise and apply non-maximum suppression to get rid of false edges.
- Then track the edges by hysteresis suppressing all the edges that are weak and not connected to the strong edges.
- Track edge by hysteresis, which finalize the detection of edge.

Output:

Figure: Edge Detection

HOUGHLINE TRANSFORM

- The HoughLine Transform can be used in image processing to detect any shape and can be represented in mathematical form.
- Lines can be detected using Houghline Transform.
- For this purpose it need the edge detected frame.
- Considering only the horizontal lines,not the vertical lines. To remove the vertical lines slope is obtained.
- The slope of the vertical line does not exist.It cannot divide by zero ,which is of-course why this slope value is undefined.
- Slope a horizontal line is zero. So,only the slope ranging from 0 - 0.15 is considered.
- Further operations are considered only when satisfying this range,else are not proceeded.
- Two parameters like minimum value and maximum value of the line is determined.Those lines coming in between to the values are displayed,others are not.

Output:

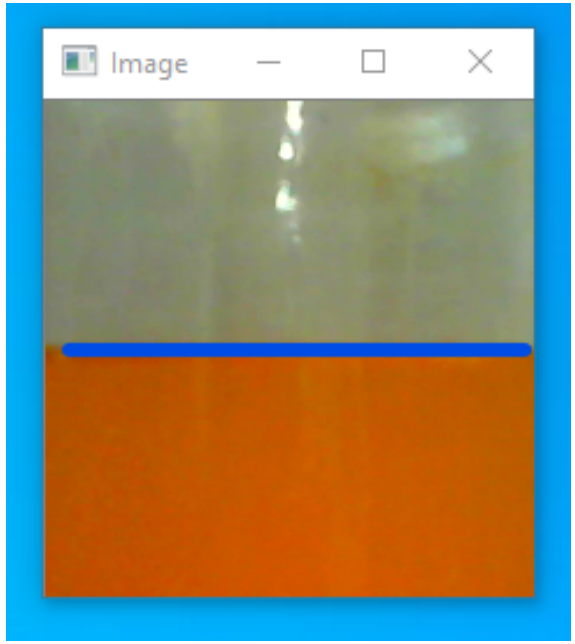


Figure: Line detection using Hough Transform

HEIGHT ESTIMATION AND PREDICTION

- After the edge detection and HoughLine Transform process it can clearly see the water level detected by the line.
- The change in the coordinates of the line is used to plot the graph. Here with the points it use the linear regression method.

Output:

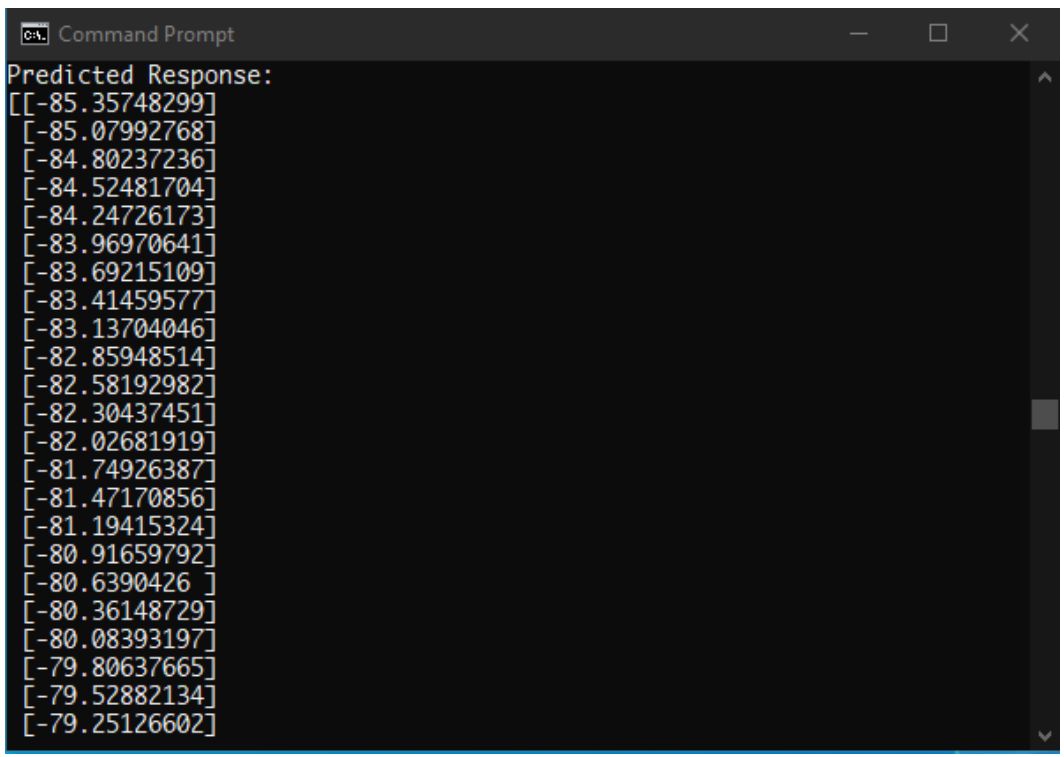
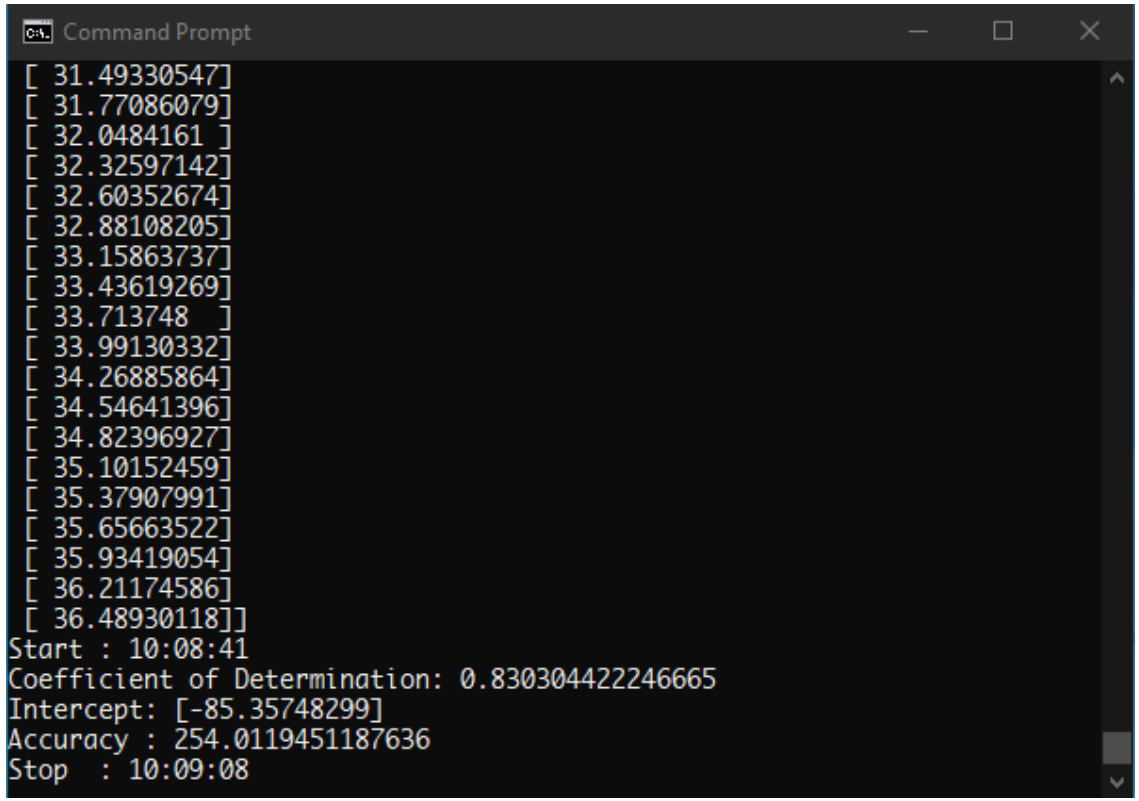


Figure: Final Output



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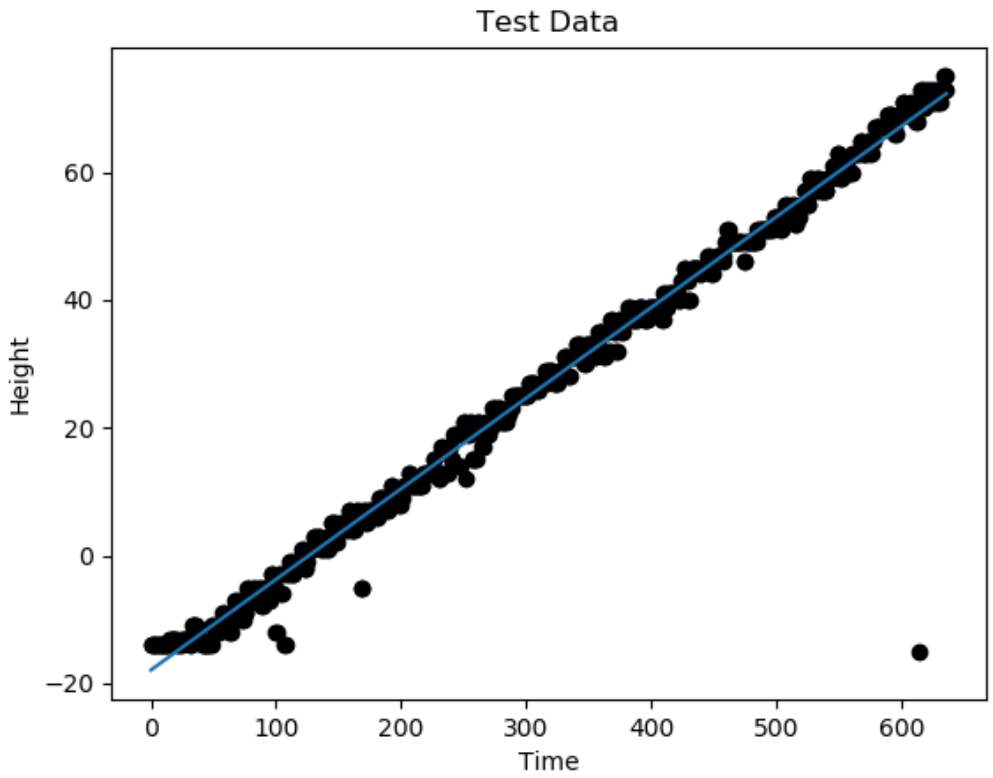

Figure: Graph

Analysis		
Sl no	Speed	Accuracy
[1]	3.79	14.91
[2]	1.73	13.8
[3]	4.61	11.3
[4]	3.19	24.2
[5]	5.35	21.1

Table: Analysis

Future scope

- Thus, an efficient and also a cheap solution to a real time Flood monitoring and early warning system could be provided with plenty of potential for further improvements and optimization on the system side.
- These experiments were performed at the same camera distance and ambient weather condition.The effect of distance can be added in the next modification.
- As a future modification one could integrate the camera into an Unmanned Aerial Vehicle platform
- so that it can be used to analyze real time flood level by moving over water and into remote areas, which is a more complex extention.

Conclusion

- Here we describe the project flood level monitoring and early warning system via computer vision techniques.
- These are basically implemented under Python with the use of the OpenCV Computer Vision Library.
- As already mentioned, the entire application is primarily running on a raspberry pi 3 single chip-card computer.
- Though the setup was prototypical, we can lay a foundation for future expansion into this work.
- Therefore, the developed approach is very flexible in terms of adaptations and can be used under real world conditions.

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Thank you