

# WATER LEVEL INDICATOR IN A PAPER CUP USING IMAGE PROCESSING TECHNIQUES

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## Abstract

LabVIEW and Vision Assistant are two tools that can be used to create many useful applications in image processing.

In this paper we applied image processing techniques like the image analysis, processing, morphology, shape matching and edge detection to design a system that can calculate and determine the amount of water present in a cup. The system takes a top view photo of the cup and uses image processing techniques to detect three significant elements (bottom, water, and top circles respectively). Such elements contain the Area and Edge information which are necessary for the computation of the percentage of water. The value obtained from each transaction was compared to the theoretical computation of the system to verify if the system can produce correct results.

In the future, this application will be added as a new function of the “Intelligent Drinking Water Machine” for the purpose of helping the blind recognize how much water is present in the cup without seeing or touching.

**Keywords:** Vision assistant, LabVIEW, image processing, image analysis, water level.

## I. Introduction

Nowadays, there is a wide range of available water level indicators. Recently, high quality liquid level indicator circuitry was developed but none of which, uses image processing.

We use image processing for indicating the water percentage in the cup, since it is fast and can help us to monitor the processing result in advance. The system is simple because it uses software instead of hardware.

## II. Materials and Methods

### Materials:

These materials are required for the successful execution of the design.

- LabVIEW Software 8.5
- Vision Assistant Software 8.5
- Camera for taking pictures
- One Paper Cup
- Mineral Water or any clear water will do.

- Measuring cup for manually measuring the amount of water in the cup.
- Vernier Caliper to measure the dimensions of the cup.



Fig.1: Experiment Cup and Vernier Caliper

### Methods:

There are many aspects of image processing techniques such as imaging condition (lighting distribution, camera characteristics, and resolution) and object position. Therefore we have to consider a lot of things and do many tests to get the best output and make sure that the algorithm is correct for all possible cases.

After testing, we will introduce the following methods that will be used for the successful execution of the system.

Step1: Set up conditions for taking the picture

- Choose the best lighting condition.
  - ✓ Light is distributed throughout the surroundings
  - ✓ No shadow is present
- Fix camera position for all experiments
  - ✓ Placed on top of the box facing the top view and center of the cup.
- Camera Setting
  - ✓ Adjust the focus to get the clearest water circle.

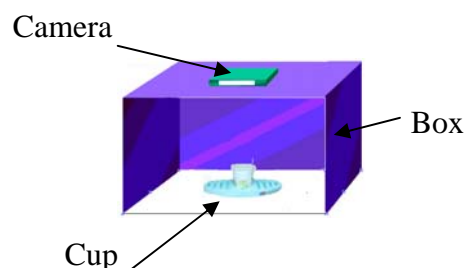


Fig.2: Set up condition

Step2: Measure the water level manually

- + Case1: No water (0% - 10%)
- + Case2: 25% water
- + Case3: 50% water
- + Case4: 65% water
- + Case5: 70% water

+ Case6: Full of water (90%-100%)

Step3: Take pictures for all this cases

Step4: Process the image following this flow chart

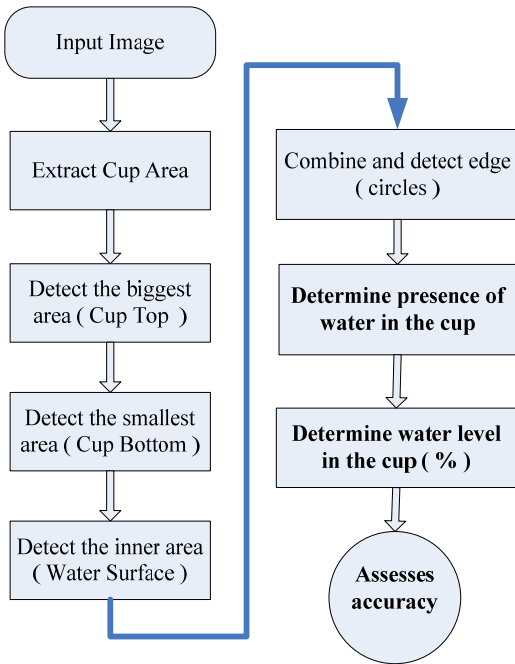


Fig.3: Processing Flow Chart

- **Extract cup area:** Because we want to minimize the processing time, so we extract the cup area for processing.



Fig.4: Cup area extraction

The group of functions used are “Morphology “, “Color Utilities”, Shape Matching and Image Extraction.

- **Detect the biggest area:**

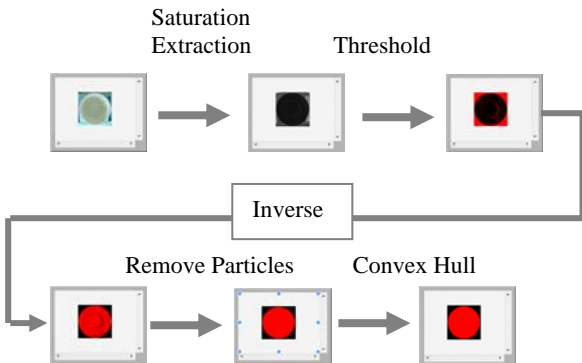


Fig.5: Biggest Area detection flow

- **Detect the smallest area:**

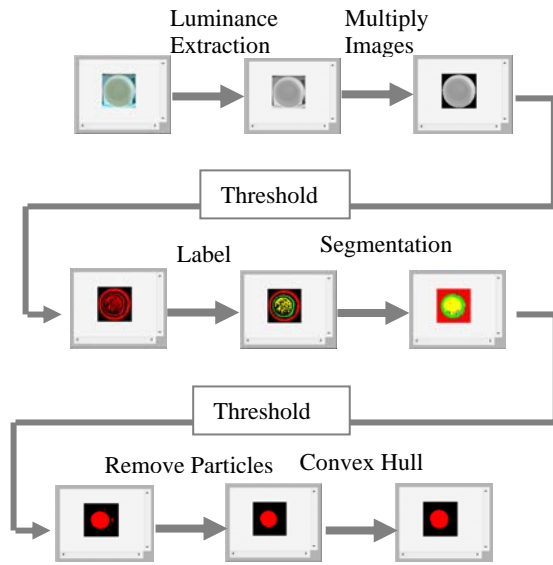


Fig.6: Smallest Area detection flow

- **Detect the water surface area:**

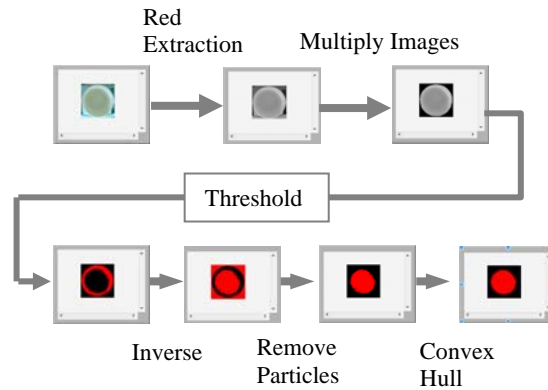


Fig.7: The water surface detection flow

After undergoing these processes, all the detected areas will be combined and the edges are also detected.



Fig.8: The edge detection image

Based on the edges, we will calculate the percentage of water in the cup.

- **Determine the presence and the percentage of water in the cup.**

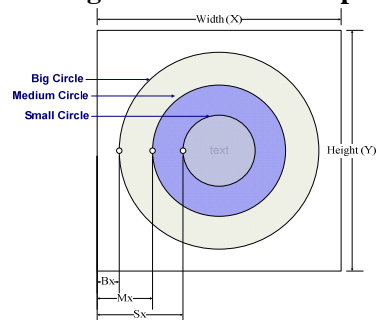


Fig.9: Parameters the of extracted area

$$AP_{V_w} = \frac{S_x - B_x}{S_x - M_x} 100$$

Equation 1: Actual Percentage of Water in the Cup

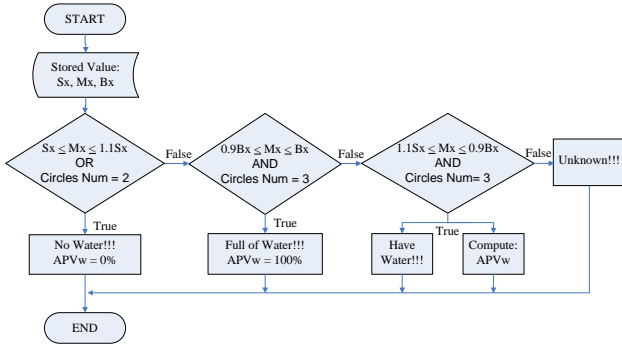


Fig.10: Algorithm Block

### Step5: Verifying the system

To know if the value of the  $AP_{V_w}$  acquired from the previous step is correct we need to add a verification block. The verification block that is shown in Fig.14 will require the user to input the dimensions of the cup and the assumed water content. Equations used here were derived from the volume of a frustum with a right circular cone and also similar right triangles.

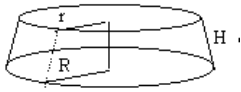


Fig.11: Frustum of a right circular cone

$$V = \frac{\Pi H}{3} (R^2 + Rr + r^2)$$

Equation 2: Volume of a right circular cone

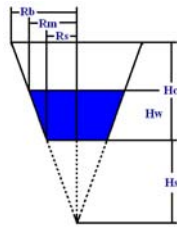


Fig.12: Dimension of the Cup

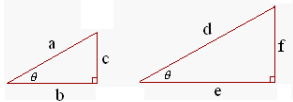


Fig.13: Similar Right Triangles

$$\frac{a}{d} = \frac{b}{e} = \frac{c}{f}$$

Equation 3: Similar Triangles

### (a) Equations used

$$V_c = \frac{\Pi H_c}{3} (R_b^2 + R_b R_s + R_s^2)$$

$$H_s = \frac{R_s H_c}{R_b - R_s}$$

$$V_w = \frac{\Pi H_w}{3} (R_m^2 + R_m R_s + R_s^2)$$

$$R_m = \frac{(H_w + H_s) R_s}{H_s}$$

$$H_w = \frac{R_m H_s}{R_s} - H_s$$

$$P_{V_w} = \frac{V_w}{V_c} 100$$

$$P_{Error} = \left| \frac{P_{V_w} - AP_{V_w}}{AP_{V_w}} 100 \right|$$

### (b) Legends

Standard Dimension of Cup:

Height of Cup,  $H_c = 82.31$  mm

Radius of Big Circle,  $R_b = 33.94$  mm

Radius of Small Circle,  $R_s = 24.35$  mm

Maximum Volume of Cup,  $V_c = 221631$  mm<sup>3</sup>

Imaginary Height,  $H_s = 208.994$  mm

Assumed Volume of Water in Cup,  $V_w$

Radius of Medium Circle,  $R_m$

Height of Water,  $H_w$

Theoretical Percentage Volume of Water in Cup,  $P_{V_w}$

Actual Percentage of Water in Cup,  $AP_{V_w}$

Percentage Error,  $P_{Error}$

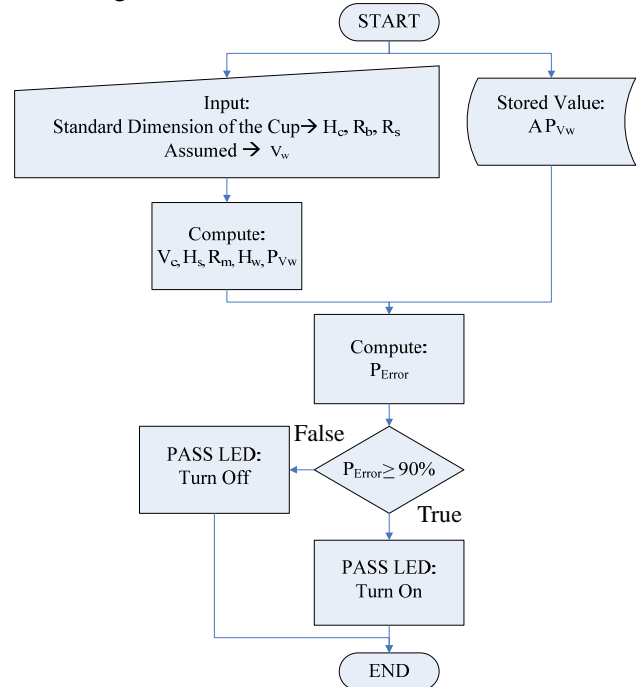


Fig.14: Verification Block Flow Chart

### III. Results and Discussions

**Results:** For each case of the experiment, the result of the image processing includes extracting the area and the edge of the images, displaying the

percentage water level and the percentage error (refer to Fig.15 unto Fig.20). We used ten images per case to test the system performance.

Water Level	PError Ave. (%)	Processing Time (ms)
Case1	$8.65 \times 10^{-317}$	1216.8
Case2	1.55111	1539
Case3	1.99835	1968
Case4	0.23277	2558.4
Case5	0.21298	2755.2
Case6	1.09931	3837.6
Max	1.99835	3837.6

**Discussion:** In our study, we have performed a lot of experiments with different cases. For the future, we will try to expand the scope of the system to more advanced cases such as:

- Different cup types and shapes.
- Other kinds of cups with varying colors.
- Rejecting the light effect as much as possible.

These things are also the limitations of this paper.

#### IV. Conclusions

Using image processing techniques (image analysis, processing, morphology, shape matching and edge detection), we were able to successfully implement our objectives, such as detecting the percentage volume of water inside the cup in all the said six cases with a percentage error of less than two percent. The features of the water, that are very useful for our study, were enhanced and extracted from the image. Besides that, the effect of imaging condition will be reduced if we use a camera that have a high resolution, so as to make the water surface to be seen clearly but this will also make the system run slowly. This can lead to a much higher cost of the system.

#### V. References

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+cups&hl=en&ct=clnk&cd=18&client=opera [8] <http://www.themathpage.com/aTrig/trigonometry-of-right-triangles.htm>

Fig.15- 20: (a).Extracted Area and Edge Detected Image, (b).Percentage Water Level, (c).Percentage Error

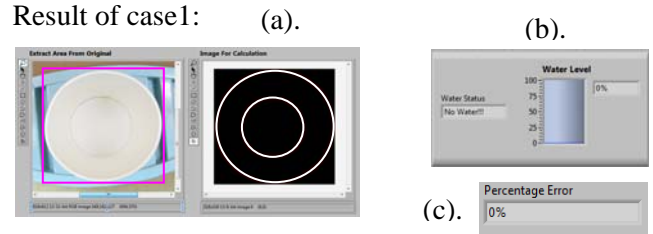


Fig.15

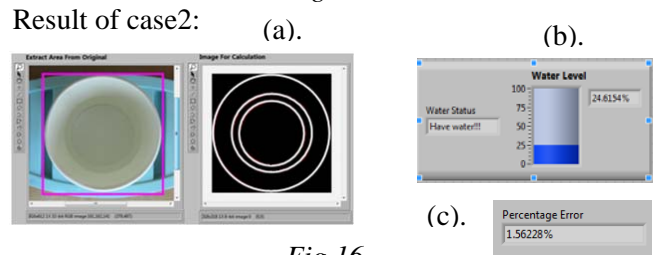


Fig.16

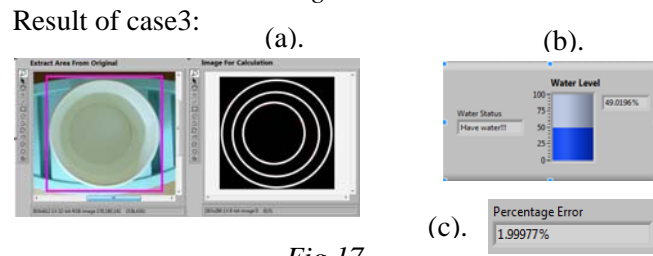


Fig.17

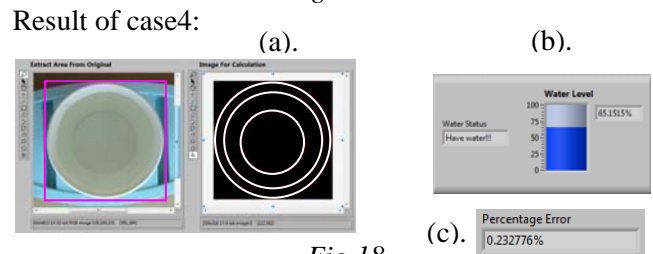


Fig.18

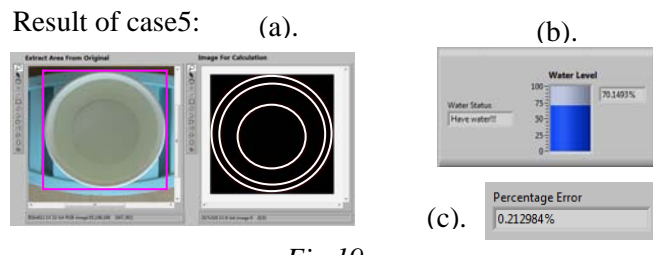


Fig.19

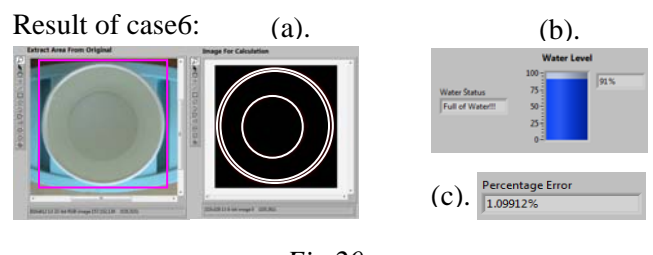


Fig.20