https://doi.org/10.36375/prepare_u.iei.a196

A smart phone application to evaluate candle frame characteristics

Abhay Chatterjee[1], Thangaraja Jeyaseelan[1]

[1]School of Mechanical Engineering, Vellore Institute of Technology, Vellore - 632 014, India

Phone (Office): +91 416 2202268 Fax: +91 416 2243092

Corresponding author's email: thangaraja.j@vit.ac.in

Abstract

Today, smartphones are used for a variety of applications it is not limited to calling and receiving, and sending text messages, they have a variety of features such as a camera, torch, games, social media, news, and so on. This paper aims to utilize the device for yet another application that is capturing the flame height, wick width, and flame width using a smartphone camera. The experimental setup is quite trivial; the camera should be as close as possible to the flame, the reference length has to be measured to have an idea about the total length captured which aids to calculate the pixel length of the image. Further, the change in height and width with respect to time is also recorded.

Keywords: Image processing; Candle flame; smart phone; python

1. Introduction

A smartphone is used for various applications in today's world. A smartphone is a very common device that is used by almost everyone these days. It is already used for various applications such as maintaining the caloric balance in the human body [1]. Furthermore, there are applications such as ithlete™ which determine ultra-short-term heart rate variability [2]. Covid-19 pandemic has made a huge impact on each one of us in some way or the other, mental health of the youth being one of the major issues, but a smartphone application on assessment and management of youth mental health could help in reducing the anxiety and depression cases among youths [3,4]. GeoTools is another android application that aids to do tasks in the area of geology, such as being a pocket compass [5].

According to the literature, there are about 76% of undergraduate students use smartphones for educational purposes [6]. Some studies aim to incorporate learning via smartphones Supadi et al. recorded a positive impact when smartphone application was used for mathematics learning [7].

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A feedback survey on undergraduate students for academic library applications was taken and it suggested that students were willing to utilize the applications [8].

The candle flame dimensions can help us to understand diffusion flame characteristics, help to facilitate industrial design, and help in understanding ignition potential. The flame height characteristics also help in the characterization of the soot formation [9]. Sunderland et al. developed a model to predict flame width and heights by capturing the length and width of the wick with a high-resolution camera and utilizing the Rayleigh number and Nusselt number for their model [10]. This paper aims to provide a simple methodology and a basic setup to capture the wick width, flame height, and flame width. The model suggested in this paper facilitates that a common person without any laboratory equipment can capture the flame dimensions and process it with an open-source language python. Subsequently, the variation in these parameters are noted which could give us an insight into how much wax is burned in a candle flame in every frame.

2. Methodology

2.1 Experimental setup

The candle has to be placed as near as possible to the reference length. Reference length is the pre-measured length, the length should include the whole flame height, for example, if the flame height is about 40mm the references length should be at least 50 mm. The camera should be as near as possible to the flame, if we increase the distance of the camera the measurement error would increase.

2.2 Model

The model was made utilizing OpenCV library from an open-source language python. The image as captured on the phone is now ready for further processing. The noise is reduced using medianblur (appropriate Kernel size has to be selected) as this blurring preserves edges that are in our interest for the calculation of flame height and flame width. After that use canny (using appropriate threshold values) to get the edges. After that number of pixels between the edges is counted and the pixel length is multiplied to get the appropriate results. This is repeated for the various frames and the variation in height and width can be observed.

3. Results and discussion

The candle was kept close to the white paper which was 63mm in length (reference length, that is the height of figure 1). The camera was placed in such a way that the whole length just fit in the frame and the lens was as close as possible. The video was captured with a Nokia 7 plus phone, with 30fps. Then the frames were extracted using the OpenCV library in python, as shown in Figure 1. After getting the frames noise reduction is done using medianblur, we can use the same or different kernel size for detecting appropriate height and width which depends majorly on the lighting and the background of the taken image. In this case for the height calculation, the kernel size is 23, the wick width the kernel size is 81, and for the width calculation, the kernel size is 121. The built-in function

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of OpenCV, cv2.canny is used to get the edges with appropriate thresholds of the in as shown in Figure2.

Figure 1: A sample Frame from the video of the candle burning

Figure 2: Image showing edges for the height calculation

Now the pixel length has to be calculated as 63mm = 3840 pixels, which results in 1 pixel= 0.0164mm. Further, the using various kernel sizes and appropriate thresholds, the result which is shown in figure 3 is obtained.

Using the same methodology the variation of flame height and flame width is shown in figure 4 and figure 5 respectively.

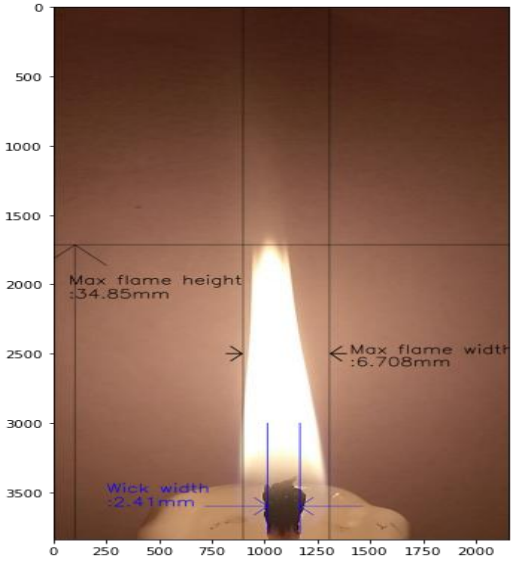

Figure 3: Image capturing critical dimensions of a flame

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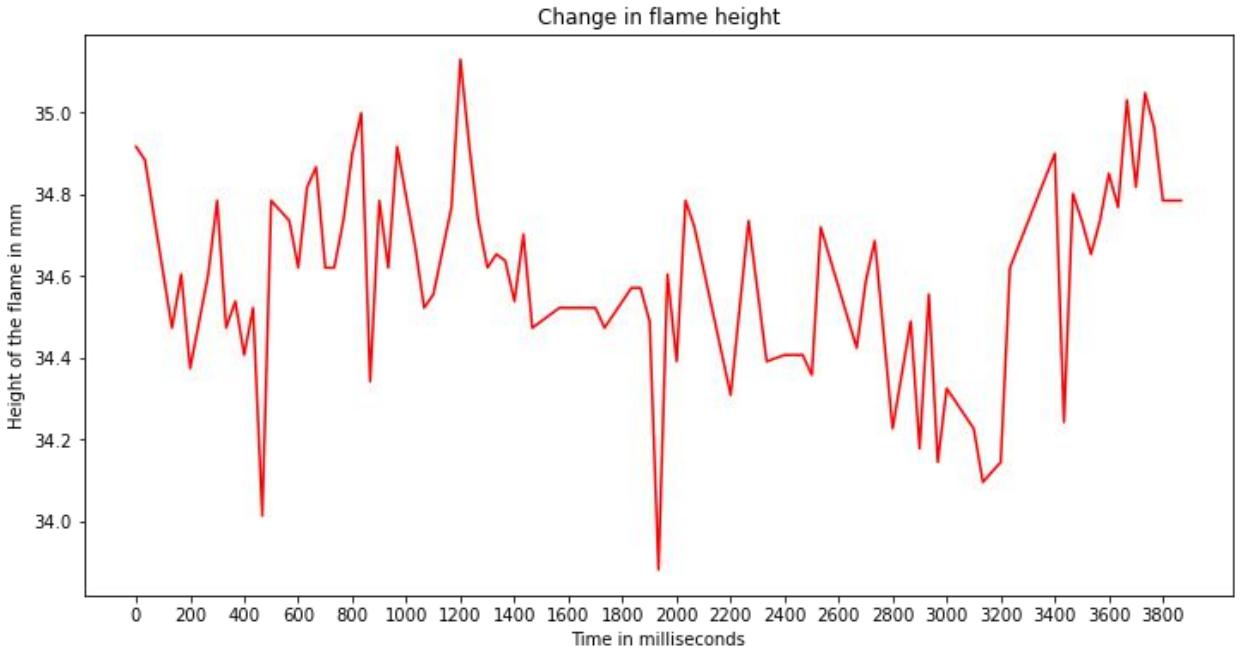

Figure 4: Change in flame height with respect to time (millisecond)

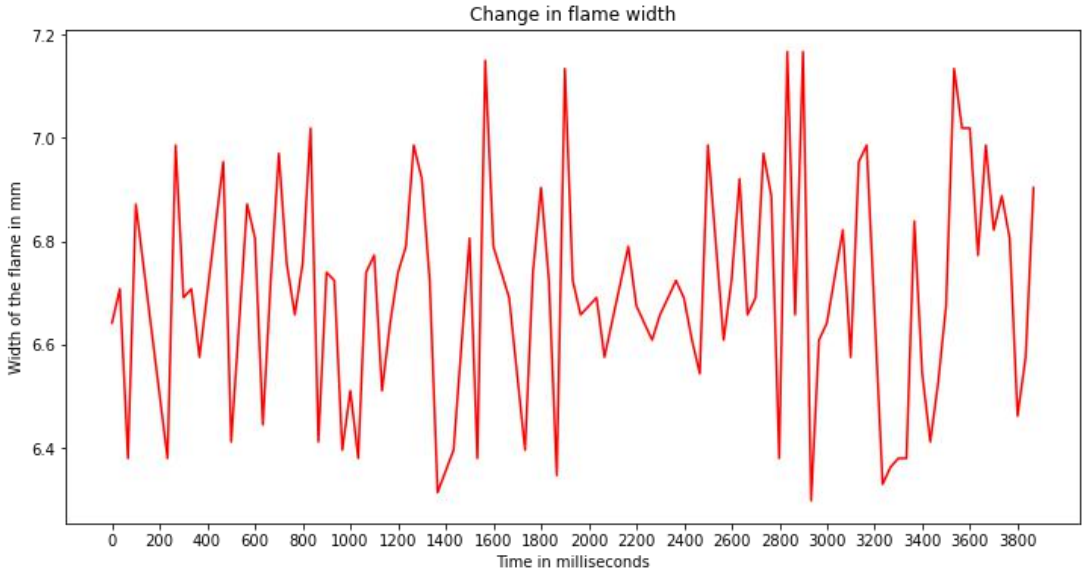

Figure 5: change in flame width with respect to time (milliseconds)

Image processing helps to easily identify the changes of critical dimensions with respect to time. The variation of the flame height and flame width can be will help in calculating various other parameters such as how much wax is burnt every frame, and other parameters similar to it. The average height recorded was

34.6 mm and the width average was 6.7 mm.

4. Conclusion

A model was put forward which is simple to perform using open source language like python and doesn't require any laboratory equipment, just a smartphone. The wick width, flame height, and its variation, and flame width and its variation are measured by this model. Which further can give us ways to calculate different factors affecting it. Further the average flame height of 34.6mm and width of 6.7mm was also recorded.

5. References

[1] Tsai, C. C., Lee, G., Raab, F., Norman, G. J., Sohn, T., Griswold, W. G., & Patrick, K. (2007). Usability and feasibility of PmEB: a mobile phone application for monitoring real time caloric balance. *Mobile networks and applications*, *12*(2), 173-184.

[2] Flatt, A. A., & Esco, M. R. (2013). Validity of the ithlete™ smart phone application for determining ultra-short-term heart rate variability. *Journal of human kinetics*, *39*, 85.

[3] https://www.unicef.org/lac/en/impact-covid-19-mental-health-adolescents-and-youth accessed at 5-11-2021

[4] Reid, S. C., Kauer, S. D., Hearps, S. J., Crooke, A. H., Khor, A. S., Sanci, L. A., & Patton, G. C. (2013). A mobile phone application for the assessment and management of youth mental health problems in primary care: health service outcomes from a randomised controlled trial of mobiletype. *BMC family practice*, *14*(1), 1-9.

[5] Weng, Y. H., Sun, F. S., & Grigsby, J. D. (2012). GeoTools: An android phone application in geology. *Computers & Geosciences*, *44*, 24-30.

[6] Bomhold, C. R. (2013). Educational use of smart phone technology: A survey of mobile phone application use by undergraduate university students. *Program*.

[7] Ariyanto, L., Kusumaningsih, W., & Aini, A. N. (2018, March). Mobile phone application for mathematics learning. In *Journal of Physics: Conference Series* (Vol. 983, No. 1, p. 012106). IOP Publishing.

[8] Karim, N. S. A., Darus, S. H., & Hussin, R. (2006). Mobile phone applications in academic library services: a students' feedback survey. *Campus-Wide Information Systems*

[9] Thomsen, M. C., Fuentes, A., Demarco, R., Volkwein, C., Consalvi, J. L., & Reszka, P. (2017). Soot measurements in candle flames. *Experimental Thermal and Fluid Science*, *82*, 116-123.

[10] Sunderland, P. B., Quintiere, J. G., Tabaka, G. A., Lian, D., & Chiu, C. W. (2011). Analysis and measurement of candle flame shapes. *Proceedings of the Combustion Institute*, *33*(2), 2489-2496.

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