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Virtual Piano Using Image Processing

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***Abstract* – It is said that there is a need of portable music devices in order to save cost, provide a similar level of satisfaction to the user as playing on a physical instrument set does. Knowing this, why should everyone have to own a costly instrument set to start playing? For our final project, I have the intention of implementing a gesture-controlled virtual piano set on BeagleBone Black using Image Processing to provide a simple and fun way for people who wish to learn or simply enjoy playing the piano. More specifically, the user's hand motion would be tracked by a camera system. The piano set uses different coloured keys to ease the motion tracking. The motion tracking system will distinguish between hitting motions in different areas in front of the user and emulate sound of distinct notes based on hitting area. At a basic level, the implementation would consist of a limited number of piano keys and basic playback of sounds of the notes the user plays. Depending on available time, other features could be added. As an example, a learning mode in which the user loads preprocessed songs and is guided which keys to play to get the corresponding output. Another idea is to provide the user with an increased number of piano set notes for increased sound options. We expect that by successfully implementing the basic functionality, the system will be robust enough so that a wide range of additional features could be completed easily.**

***Keywords* – Virtual Piano, Beagle Bone, Image Processing.**

I. INTRODUCTION

Recent technological advances have enabled human users to interact with computers in ways previously unimaginable. Image processing is the field of signal processing where both the input and output signals are images. Creating the interface between the laptop, BBB and the piano using a language that will not only give you a lot of flexibility, but it will also involve a lot of work and background knowledge of many subjects studied in Electronics and Tele Communication. Fortunately for us, MATLAB has a variety of simple inbuilt functions that can be used to create the interface. In this paper, the author has explored an intelligent method for object detection and tracking in real time video using OpenCV on ARM-9 Beagle Bone Black. Processing a video stream to segment foreground objects from the background is a critical step in many computer vision applications. Background subtraction is a commonly used method for achieving this segmentation. Gaussian Mixture-based Background Segmentation Algorithm and morphological operations are used in this paper for object detection and tracking. In the first step a video is taken as input, is divided in to frames, each frame is converted to binary frame then applying background subtraction algorithm to detect the moving objects.

II. OBJECTIVE

This project aims at creating a "Virtual Piano using Image Processing". Our focus is on creating an affordable virtual and portable piano kit for amateur piano players using image processing using MATLAB functions.

To achieve this, we will be using the concept of colour object tracking. We will be tracking blue colour object. We use blue colour on our finger tips to perform the same. The screen is of the resolution 640x480 which is virtually split into seven sectors each of which represents Sa, Re, Ga, Ma, Pa, Dha, Ni.

III. THEORETICAL BACKGROUND

Creating the interface between the laptop, BBB and the piano using a language that will not only give you a lot of flexibility, but it will also involve a lot of work and background knowledge of many subjects studied in Electronics and Tele Communication. Fortunately for us, MATLAB has a variety of simple inbuilt functions that can be used to create the interface.

Video tracking in real time is one of the most important topics in the field of surveillance systems. Detection and tracking of moving objects in the video scenes is the first step in the information extraction in many computer vision applications. In this paper, the author has explored an intelligent method for object detection and tracking in real time video using OpenCV on ARM-9 Beagle Bone Black. Processing a video stream to segment foreground objects from the background is a critical step in many computer vision applications. Background subtraction is a commonly used method for achieving this segmentation. Gaussian Mixture-based Background Segmentation Algorithm and morphological operations are used in this paper for object detection and tracking. In the first step a video is taken as input, is divided in to frames, each frame is converted to binary frame then applying background subtraction algorithm to detect the moving objects. Erosion and Dilation Morphological operations are performed on these frames to remove the unwanted shadow, tracking and labeling the moving objects. The main processing unit is an ARM Cortex A8 processor based Beagle Bone Black (BBB) with Linux (Ubuntu) operating system installed with OpenCV. The indexing of identified objects and automatic labeling enables the developed system suitable for surveillance applications.

IV. Technical Approach

To execute this project, we will be using the following:
Hardware: 1) BeagleBone Black 2) Logitech C-270 720p Webcam
Software: 1) MATLAB R2011a, R2014a 2) Windows OS

Block Diagram

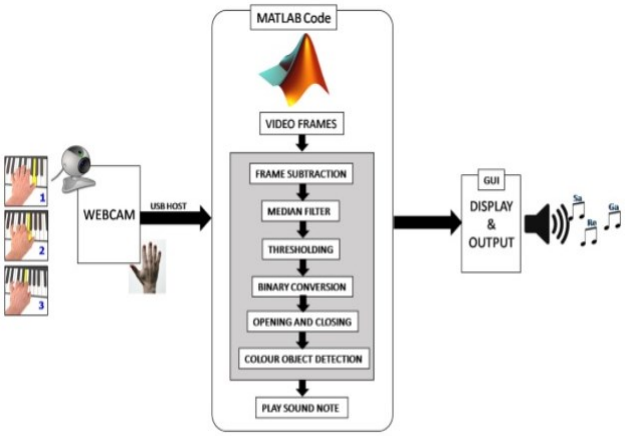

Fig. 1. Block Diagram

A web-camera is mounted vertically on a mount. It captures the area over which the piano keys are to be played. This video stream is converted to video frames. The input image frame then undergoes series of extraction and segmentation operations. The output result of extraction and segmentation is compared with the previous image frame using image subtraction. This enables us to track the blue colour object in the video. We can also configure the code to be able to track different colours like red or green. When the colour object is tracked in the particular segment, the corresponding sound note is played. These sound notes are generated using mathematical equations. We can play Sa, Re, Ga, Ma, Pa, Dha, Ni using this approach

V. Virtual Piano

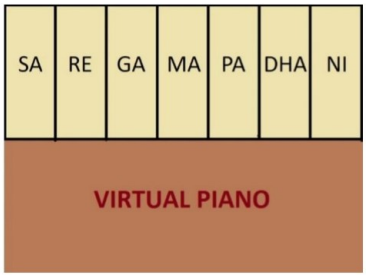

Fig. 2. Virtual Piano

The MALTAB code is designed to acquire video frames using the Image Acquisition Toolbox. The Logitech C-270 720p web-camera is interfaced with the code. This camera is vertically mounted on an aluminum stand. When initiated by the GUI, the webcam starts to acquire video frames and perform operations so as to obtain the desired result.

We use a series of operations on the video frames as listed below: 1] Frame Subtraction 2] Median Filtering 3] Thresholding 4] Binary Conversion 5] Opening and Closing 6] Colour Object Detection.

VI. Comparison With Other Similar Techniques

The Virtual Piano has been implemented in a number of different forms in some case, player has to press a keyboard specific key to get a specific key note it, is difficult for the user to learn the analogy between the keyboard and the piano as described by Adajania, Gosalia, Kanade, H. Mehta, Prof. N. Shekokar, Kölsch, M. and Turk, M of these, the ones based on 3-D optical ranging and CCD cameras are most significant as they are based primarily on image processing. The elaborate research done by Kölsch, M. and Turk, highlights a variety of virtual keyboards in different forms, such as gloves, rings, hand gestures based and projection based devices. In, a special 3-D camera, or two 2-D cameras are used. Additionally a pattern projector is used for projecting the keyboard. The VK designed in makes use of a single CCD camera. Even more significant is the work presented in, where a shadow based analysis is used to acquire depth information from a 2-D image. To generate sounds we used frequency equations. We could have used recorded sound notes but this decreases the speed of the code. To, enhance this we have used frequency equations which are used with different frequencies. Each of Sa, Re, Ga, Ma, Pa, Dha, Ni has different frequencies. We use the novel technique of using image processing using a web camera. Our idea is to eliminate complexity in playing a keyboard and to make the piano a portable virtual piano. Our design is an entertainment tool which could be used by anyone who is interested in music playing but don't have a piano keyboard.

VII. Working in Detail

The above steps have been explained in detail below:

- Frame Subtraction: Image subtraction or pixel subtraction is a process whereby the digital numeric value of one pixel or whole image is subtracted from another image. This is primarily done for or detecting changes between two images.
- Median Filter: The median filter is a nonlinear digital filtering technique used to remove noise. It is a pre-processing step to improve the results of later processing.
- Gray Scale Conversion: Grayscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information.
- Binary Conversion: A binary image is a digital image that has only two possible values for each pixel. Typically, the two colours used for a binary image are black and white, though any two colours can be used. The colour used for the object in the image is the foreground colour while the rest of the image is the background colour.

- Opening and Closing: Erosion is mainly used for eliminating the irrelevant details of an image. Dilation is mainly used to enclose holes in a single region, reduce the gaps between different regions and to fill the intrusions into boundaries of a region.
- Colour Object Tracking: Colour tracking is the ability to take an image, isolate a particular colour and extract information about the location of a region of that image that contains just that colour.

VIII. RESULT

- We successfully created set up for camera mount.
- We made calibration GUI to help user to adjust his paper printed keys with the webcam.
- We successfully created a friendly GUI for users with options of changing Note lengths and Tones.
- Beaglebone black was successfully configured with webcam and real time video was captured.
- When the user places his colored finger tip on the particular key segment, he can view the frequency corresponding to that sector and the note being played at the bottom right corner of the GUI.

We have successfully created a prototype of a virtual piano. We have successfully interfaced the camera to function as required with the MATLAB software.

We learnt, understood and implemented the core concepts of image processing. Trying the implementation through the BeagleBone Black gave us a considerable amount of hands on knowledge of the processor. We used MATLAB's Image Acquisition Toolbox and the Matlab GUIDE for successfully implementing the code. The GUI, as we desired, is user friendly and less complicated.

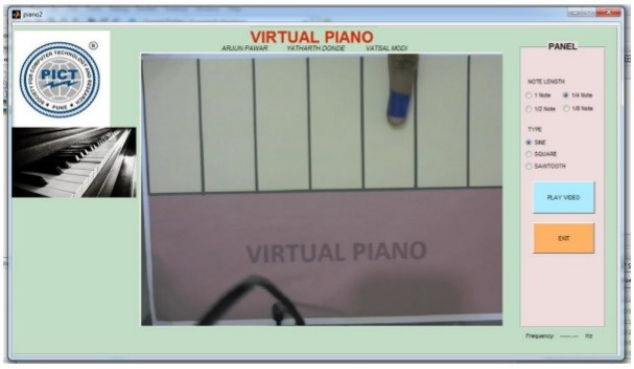

Fig. 3. Virtual Piano GUI

The above figure is the GUI of the virtual piano. It provides various options to user.

- One can choose from various effects such as square, saw tooth and sine.
- One can also choose different note lengths such as full note, half note, quarter note, etc.
- He is provided with two buttons to start video capture and to exit from the GUI.

When the user places his coloured fingertip on of the sectors, he can view the frequency corresponding to that sector and the note being played at the bottom right corner of the GUI.

IX. CONCLUSION

This report contains a detailed overview of what is required to bring about the success of the project. The implementation of this idea will enable many to learn or enjoy the pleasure of playing a piano virtually.

This project provides a portable solution in contrast to carrying the large bulky instrument. Through this project, we learnt the fundamentals of image processing and also the functionalities of the MATLAB.

This approach can be used in various other applications such as virtual keyboard, virtual drums or virtual mouse. Also by modifying the code, we shall be able to implement a virtual whiteboard or any other hand gesture controlled or a percussion instrument. With a sense of adventure and some degree of technological innovation and creativity, virtual musical instruments can replace expensive physical musical instruments while delivering comparable and accurate results.

REFERENCES

[1] Transaction/Journals: [1] A Swetha, M.S.Sheeba, "Moving Object Tracking in Video Scenes in Embedded Linux and BeagleBone", Department of E.C.E, Satyabhama University, Chennai, Tamil Nadu, India, pp. 764-768, March 2014.

[2] B. Dhananjaya, B. Rama Murthy, P. Thimmaiah, "Moving Object Tracking with OpenCV on ARM Cortex-A8 in Surveillance Applications", Dept. of Electronics, Sri Krishnadevraya University, Anantapur, A.P., India, pp. 843 – 848, April 2015.

[3] Shubham Srivastava, Pratibha Singh, "Real-Time Object Tracking Using Colour Feature", International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-3, Issue-8, pp. 56 – 59, January 2014

[4] Books:] S Jayaraman, S Esakkirajan, T Veerakumar, Digital Image Processing; McGraw Hill Education (India) Pvt. Ltd., Green Park Extension, New Delhi 110 016, 2009, pp. 543-578

[5] Interactive Offline Tracking for Color Objects: Yichen Wei, Jian Sun, Xiaoou Tang, Heung-Yeung Shum
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