DSP LAB PROJECT REPORT
VIRTUAL DRUMS

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Introduction

Virtual music instruments sense a triggered stimulus in an interactive environment and produce corresponding rhythm in real time to resemble live music. In this project, I replicate a drum-kit in which I take input from the webcam of a laptop, use Image processing in real time to determine the intention of a drummer in a virtual setting and play corresponding music as if the drummer was playing with an actual drum-kit in front of him/her.

The drum kit, which is also usually referred to as “the drums” consists of an arrangement of percussion instruments so that they can be played by an individual. The number of Percussion instruments in a drum kit is not fixed but consists of a combination of large drums, small drums and cymbals (Cymbals is a thin, round, plate-like percussion instrument). There is no standard configuration for a drum kit but usually drum kits consist of a five-piece set, including a snare drum, a floor tom, a bass drum and two tom-toms. A typical drum kit is shown in the figure below. Our model consists of 4 drums namely hi-hat, snare, tom and ride. An individual playing virtual drums does not find it hard to transition between 4 instruments in virtual air space, this is the reason why 4 instruments are chosen as compared to more number of instruments. The reason for choosing these four instruments (sounds) are to mimic a broad range of music experience as all the four instruments chosen produce relatively different sounds. Hihat consists of two stacked cymbals and produces a short, crip and muted percussion sound. Snare produces a short, bright sound. Tom produces a high tone and a Ride maintains a steady rhythmic pattern.

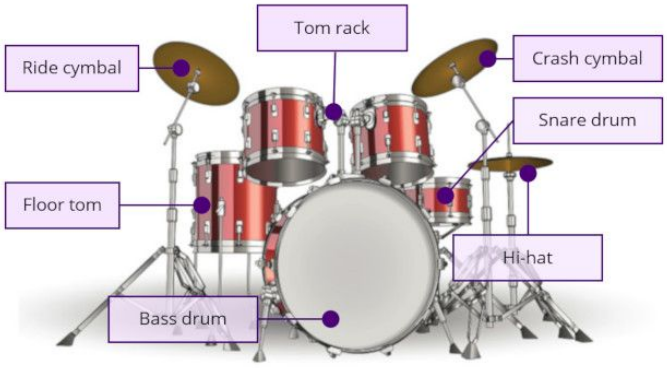

Fig: A typical drum set with parts labelled
(https://musicalinstrumentguide.com/parts-of-a-drum-set/)

Methodology

The system generates appropriate sounds by tracking the movements of the drumsticks from the live video stream in real time. Spatial position and velocity during the time of impact is of utmost importance to us. The spatial position of the drumstick determines the instrument in the drum-kit being played. Ride is the leftmost instrument, next comes Snare, the Tom and rightmost is HiHat. The velocity just before the impact determines the volume of the corresponding instrument sound produced.

Fig 2: Virtual Air drums
(Image taken from the link mentioned in Reference section point 3.)

Implementation

Design includes video stream capture and processing of the video frame-by-frame in real time. The block diagram and the actual implemented picture of the virtual drum kit is mentioned below.

The design implementation mainly consists of three parts:

1. **Localization of drum-stick**

   For Each frame of the video, we demarcate each drum-kit instrument with two nested rectangular boxes. The outer box is used for localization of drumstick and to find the centre of the drumstick tip. Localization of the drumstick is based on color extraction inside the localization box. Once we have the position of the drumstick tip centre, we use the inner box for further localization. We use the continuous position of the centre of the drumstick tip in consecutive frames and a combination of outer and inner rectangles to determine if the drumstick was struck.

2. **Motion Analysis**

   To perform motion analysis, we mainly concentrate on the centre of the drumstick tip. We continuously record the location of this centre across multiple frames. We then determine the speed of motion based on the rate of change of drumstick centre localization across several frames just before impact of the drumstick to any of the instruments.

3. **Sound Generation**

   Sound generation module uses the above calculated spatial information and the velocity of the drumstick tip to generate appropriate sounds. Corresponding sounds are generated for each instrument using pre-recorded wav files. “Ride” which is one of the drum kit instruments used in this project is mainly used for providing rhythm, so for this reason, we do not consider the strike information to produce “Ride” rhythm, we measure any change in

localization of drumstick inside the localization box and produce slightly delayed “Ride” sound which acts as a background rhythm for the drum kit.

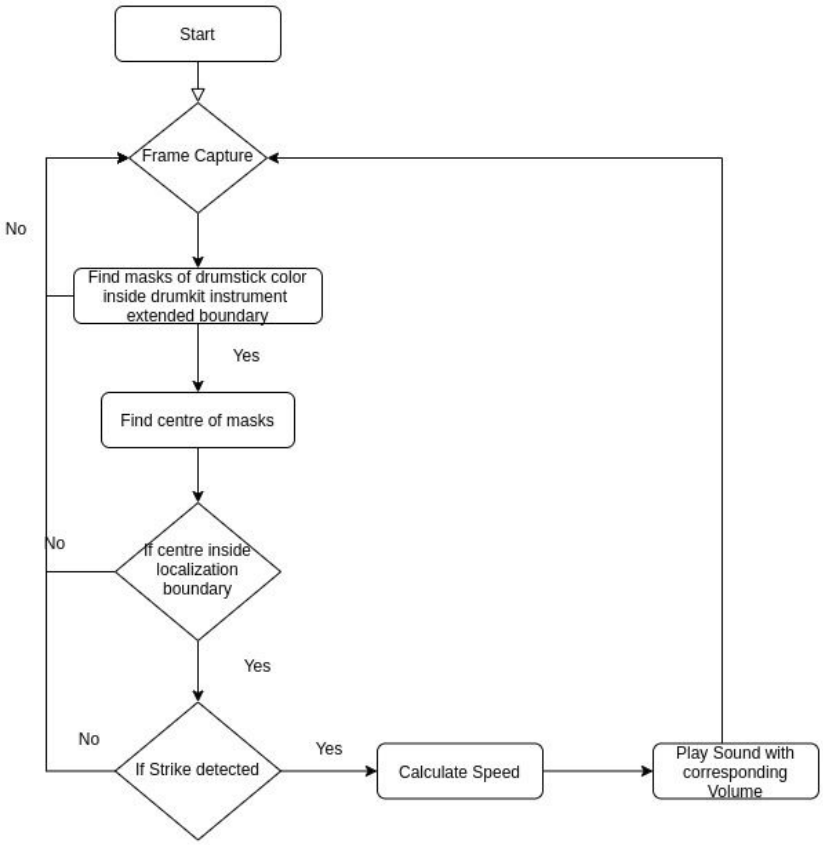

Fig 3: Block Diagram of the implementation

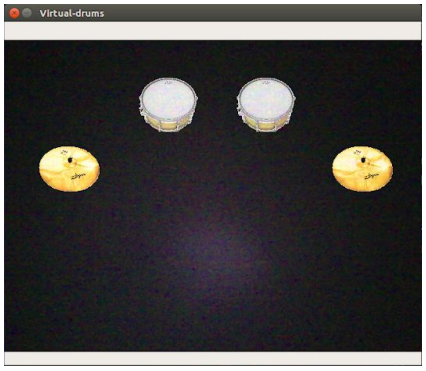

Fig 4: Window of the implemented Virtual-drums.
The four drums and its location can be seen. The bright color in the bottom centre is the region which is best suited for the drummer to reach all the drums for the best music experience. The picture was taken in a dark background for better representation

Software code and Libraries

Along with this report, I've submitted the software code developed based on the methodology and implementation mentioned above. The code contains one file in the name "virtual_drums.py". The entire code was developed by me using library documentations and referring to corresponding technical community forums when encountered with complications. I've only used open source libraries for my project. I've used Python language for development and the details of the libraries and a few important functions are mentioned below.

1. **OpenCV:** For video capturing, image processing and display.
    a. cv2.VideoCapture(): To read input video stream from webcam.
    b. cv2.inRange(): To get masks of colored objects inside a given range
    c. cv2.findContours(): To find contours
    d. cv2.moments(): To get centre of the contours
    e. cv2.imshow(): To display the frames to form a real time video
2. **Numpy:** For High-level numerical functions.
3. **Pygame:** Mainly a video game platform, used in this project for playing sounds
    a. pygame.mixer.Sound(): For loading sounds
    b. play(): For playing sounds with volume controls

Conclusion and Future Scope

In this project, I have developed a virtual drum kit with 4 drums with various added functionalities such as playing drums only when a strike is detected, using the speed of motion for changing volume, etc. The model was tested on an Intel-i5 processor and yielded an output rate of 14.51 frames-per-second with an input of 14.79 frames-per-second which is considered within the limits of real time image processing. This project can be further improved by porting to devices such as mobile phones, tablets, etc. Two or more devices with this application can be synched to produce music jamming sessions.

Reference

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