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FGEST: FINGER TRACKING AND GESTURE RECOGNITION IN SMARTPHONES

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Abstract

Recent advances in mobile processors have made complex calculations possible and feasible in Smartphones. Taking advantage of these developments we aim to develop a gesture recognition application that can recognize finger movements effectively in a variety of lighting conditions and perform corresponding actions. This enables us to incorporate a new form of interaction on mobile devices without using extra hardware as it utilizes the front facing camera present in most mobile phones. Here we present a framework that describes our application which will increase the functionality of preexisting devices.

Keywords-video analysis,edge and feature detection, motion, shape, tracking

I. INTRODUCTION

Smartphones have completely revolutionized the mobile phone industry in the last five years. Mostly touch-screen devices, they capitalize on human being's natural instinct to touch and feel. Smartphones have brought the world closer, providing one–touch access to all the information desired by the user. These phones are usually characterized by interactive interfaces and a superior user experience.

Developers across the world are trying to further enhance this user experience. From numeric keypads to qwerty keypads to touch-screens, the technology is ever-revolving. Research is going on to make the interface touch-independent, so as to make it possible to access the device even from a distance.

A lot of work has been done in this field on Windows platform, yet the Android platform is still virgin. Recently, Qualcomm, using a prototype tablet running on Quad core processor, demonstrated gesture recognition on an Android platform. Sony Xperia Sola uses capacitive inductors to implement "floating touch"™ which recognizes touch action from 1-2 cm above the screen.

According to a 2012 census, 59% of the smartphone run on the Android platform. So, there is a need and possibility of an application that can further enhance user experience in Android smartphones and make it possible for users to access their devices from a distance.

The purpose of this system is to develop an Android application for tracking the movement of a fingertip. By employing the front camera that is already present in most of today's smartphones, we shall use a fingertip recognition algorithm to detect the fingertip motion using contour analysis. Finger gestures can then be associated with accepting and rejecting calls which would aid a driver. The gestures will also be used to shuffle songs and move to the next image in gallery.

As finger-tip gesture recognition is more preferred and convenient for human beings and being an unexplored idea in cellular technology, it is the main focus of this project. Also reducing overhead of processing, background subtraction, color detection, contour recognition and to avoid the problems faced by the users are the driving forces for taking up this project.

User moves his/her finger in front of the smartphone's front camera. Background detection, color detection and contour analysis are performed on the video frames to detect the finger-tip and then recognize its movement. Depending upon the movement detected and the third-party application synchronized, the necessary action is initiated.

Our application can be easily integrated with system applications like phone, gallery and music player as well as opening new avenues for application developers.

II. PROBLEM FORMULATION

A. *Problem Definition* – Given the performance of a deliberate gesture by an actor the system should interpret that gesture and send a command to a 3rd party application to perform an associated task. Gesture recognition should be robust i.e. it should work in a variety of lighting conditions and with a wide array of gestures.

B. *Problem Output* – The main objective of the FGEST is to enable a new form of interaction in smartphones without adding hardware. The added functionality will enable safe phone calls in cars, intuitive web browsing and navigation, handsfree gameplay etc.

Real time inputs will be taken from the front camera. The frames will be processed and any motion will be detected. The empirical data will be classified as gestures and the information will be sent to the application which has been selected by the user.

III. MATHEMATICAL MODELLING

We now provide a model of the system in terms of Set Theory domain.

1. Let 'S' be the Finger tracking and Gesture recognition system.

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S= {…………

2. Identify the inputs as F, F1 and L.

S = {V, L…

F = {i | 'i' is the raw video frame captured by front camera.}
= {*.mp4 }

L= {t | 't' is location of input file on hard disk drive}

3. Identify the output as O.

S = {V, L, O, R …

O = {o | 'o' is metadata of processed video frame.}

R = {r | 'r' is the desired response of the system.}

4. Identify the processes as P.

S= {V, L, O, R, P …
P= {F, M, D}

5. F is the set for finger extraction module activities and associated data.

F = {Fip, Fp, Fop}

Fip= {f| 'f' is the valid input to finger extraction module.}

Fp= {f | 'f' is the finger extraction function to convert the Fip to Fop.}

Fp (Fip) = Fop

Fop= {f | 'f' is the output generated by finger extraction module i.e. contour detection.}

6. M is the set of Motion tracking activities and associated data.

M = {Mip, Mi, MOp}

Mip= {t |'t' is valid input for motion tracking.} = Fop

Mi= {p | 'p' is the function to track Mip.}

Mi (Mip) = MOp

MOp= {t |'t' is the metafile that stores information about tracked motion.}

7. D is the set of finger motion direction detection activities and associated data.

D= {Dip, Di, DOp}

Dip= {t |'t' is valid input for direction detection.} = MOp

Di= {p | 'p' is the function to track Dip.}

Di(Dip) = DOp

DOp= {j |'j' is the metafile that stores information about detected direction i.e. x and y coordinates}

8. Identify failure cases as F'

S= {V, L, O, R, P, F' …

Failure occurs when –
F= {ϕ}

F= {p| 'p' is matching with input in less than 70% cases}

9. Identify success case (terminating case) as 'e'

S= {V, L, O, R, P, F', e…

Success is defined as- e = {p| 'p' is matching with input more than 70% similarity}

10. Initial conditions as S0

S= {V, L, O, R, P, F', e, S0}

Initial condition for finger detection- There should be considerate distinction between the finger colour and background colour i.e. IOp $\neq$ { ϕ }

There is no initial condition for motion tracking.

IV. FRAMEWORK

The basic framework for Finger Tracking and Gesture Recognition consists of 3 main phases:

Phase 1(Receive Input Frame) receives the raw video frames from the front camera and decodes these frames before sending them to the next phase.

Phase 2(Process Frames) processes those frames and applies background subtraction, skin color segmentation, contour analysis and motion tracking to recognize and interpret gestures from the given input.

Phase 3(Perform Action) receives the gesture information and commands a 3rd party application to take the necessary steps to complete the request specified.

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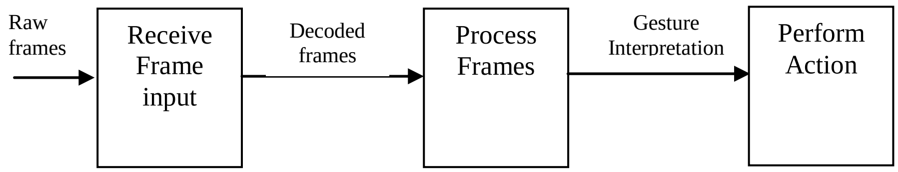

Figure 1: Basic framework for Finger Tracking and Gesture Recognition

V. IMAGE PROCESSING FILTERS

The following filters shall be used to process the frames:

A. *Skin Color Segmentation*

The first phase of the processing requires detecting the skin region in the input frame. Normally frames are in the RGB color system. RGB is not suitable for skin color detection as a variety of lighting conditions means that consistent detection of skin will not take place due to changes in skin color. To resolve this difficulty we propose to convert the RGB frames into YCbCr system which will neutralize lighting and exposure variances to improve skin detection.

$$SkinColor(x, y) = \begin{cases} 1 & if\,(77 \le C_b \le 127) \cap (133 \le C_r \le 178) \\ 0 & otherwise \end{cases}$$

This formula will be the base for Skin Color Segmentation and will be used to differentiate between skin and non-skin pixels.

B. *Background Subtraction*

To improve the accuracy of finger detection we shall, in parallel, employ a background subtraction filter. This filter shall perform foreground, background differentiation and then remove the background parts. The frames shall remain in the RGB system. The outputs of the background subtraction and skin color segmentation shall be added together to get the most accurate detection of the finger tip.

C. *Contour Analysis*

After the detection of the hand contour analysis will be used to detect fingertips. In an open hand the areas of the finger tips have sharper curvature than the other parts of the hand. Using the kCosine formula the curvature of the hand will be calculated and the area with the sharpest change in curvature will be positively identified as fingertips.

D. *Finger Tracking*

A predictive algorithm will be used for finger tracking. Using previously calculated values an area of the image will be identified as most likely to contain the finger. This area will be processed first. If no fingertip is detected within that area than the entire frame will be processed. The extra calculations required in the worst case will be offset by the reduction in calculations when the fingertip is detected in the predicted area.

VI. OPTIMIZATION FOR MOBILE INTERFACES

To counter the limited processing power and battery capacities of mobile platforms we plan to include the following modifications in our framework:-

A. *Variable Frame Processing*

During the frame capture process we plan to introduce variable frame capture rates which will depend on factors like if a supported application is running or if a valid artifact has been detected in the previous frame capture.

B. *Situational Frame Crop*

For efficient utilization of processor, we intend to run our algorithm only on the interesting area, part of the complete frame in which the valid artifact was detected, ignoring the rest of frame area, omitting unnecessary computations.

C. *Early Termination*

To reduce unnecessary processor usage we introduce variable process termination. At every stage we check to see if there are any negative detections. If any are encountered then the frame is immediately dropped and the processing pauses.

VII. EXPECTED RESULT

The expected result will be the successful detection of gestures with a relatively high probability in a variety of lighting conditions and accounting for variable distances between user and camera.

VIII. CONCLUSION

Thus we have presented a framework for finger tracking and gesture recognition using smartphones. We have also described the Mathematical Model for the same.

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