Project Proposal:

Recognition, Tracking and Association of Hands, Fingers, and Blobs: A Tbeta Upgrade

NUI Group

Mentoring Organization

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1. **Introduction**

   This Project Proposal consists on the addition of Blob, Hand, Finger Tracking and Association as core functionality to the Tbeta for using with DI approaches. If achieved, this can imply on a wide sort of applications that could be imagined and introduced by the multi-touch community using Tbeta. The idea is to try to be as much as possible "multi-touch platform independent". Moreover, this is an opportunity for introducing not only the author but his lab project to the contributors of NUI Group. That would be an honor opportunity them.
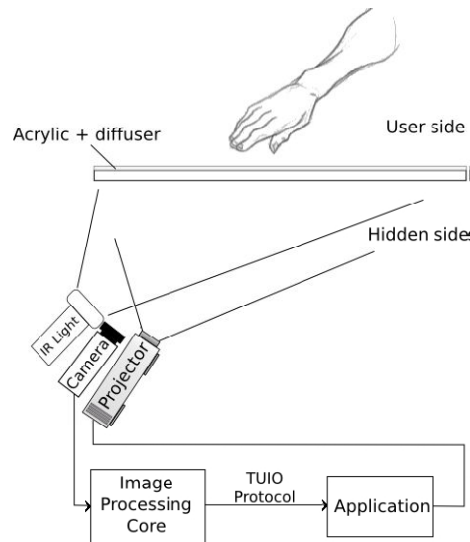

   Fig 1. *Blob Recognition*

2. **The Tbeta**

   As described by its own developers: *"The Beta, **tbeta** for short, is an **open source/cross-platform solution** for **computer vision** and **multi-touch sensing.** It takes a video input stream and outputs tracking data (e.g. coordinates and blob size) and touch events (e.g. finger down, moved and released) that are used in building multi-touch applications. tbeta can interface with various web cameras and video devices as well as connect to various TUIO/OSC enabled applications and supports many multi-touch lighting techniques including: FTIR, DI, DSI, and LLP with expansion planned for the future (custom modules/filters)."* The main aspect of this purpose is then to provide the following implemented algorithms as core functionalities to the Tbeta, in such a way that they are spread and available to every member from the multitouch community to use on its own applications.

3. **Blob Recognition**

The blobs may be found using a threshold method similarly to the one discussed in [10]. Tbeta already has a blob recognition algorithm implemented on OpenCV what eases the process of algorithms combination.

Fig 2. *Blob Recognition*

4. Finger Recognition

The problem of finger recognition is a relatively well studied topic [16] [17] [18]. Sigurdsson and Wong discuss finger recognition for cropping applications [16], Malik investigates the real-time finger tracking for interaction with computers [17] whereas Letessier and Berardand study specifically the finger tracking problem in interactive displays [18]. Concerning the finger recognition and tracking, some interesting solutions were proposed, such as crevices detection [19] used for tracking fingers on a pianist hand. The missing corner is the dual association between those fingers and the hand, what is necessary for our proposed applications. The current approach that I have implemented, restricts the finger recognition to the HROI (Region of Interest where a Hand was found) and so it becomes quite simple, and mainly based on the Sobel [20] Gradient on the Y direction (Figure 3). A(x; y) denotes the digital image taken from the camera which after the gradient transformation is forwarded to the edge detection based on the Canny Algorithm [21]. The Hough lines based algorithm [22] has been evaluated, however in the final implementation the detector was based on the border following algorithm proposed by Suzuki [23]. As a result, the finger positions can be obtained and an ID may be associated, similarly to what has been done for the hands.

Fig 3. *Finger Recognition*

5. Hand Recognition

The hand recognition approach already implemented was based on the state of the art work of Viola and Jones [11] using Haar-like features [12] as shown on Figure 4. The method allows very fast feature evaluation because of the image representation as an integral image [11]. Kölsch and Turk [13] implemented and analyzed the application of the same method on a hand detection system and obtained interesting results, although criticizing the costs for a computationally expensive training method, what prohibits the evaluation of many hand appearances for their suitability to detection. Ong and Bowden [14] state that the training may have an excessive number of weak classifiers for each strong layer. However, on our system the hand positions are not as flexible as the analyzed on those systems, in such a way that the main hand positions may be evaluated by the classifiers and the high accuracy performed by the detector is adequate to justify the "one-time"costs for training. However, there is an ongoing study

for this algorithms as all the aspects are wanted to be independent of platform to be more easily integrated to Tbeta. Specially,Pseudo-Hand Tracking seems to be a very interesting approach to this task.
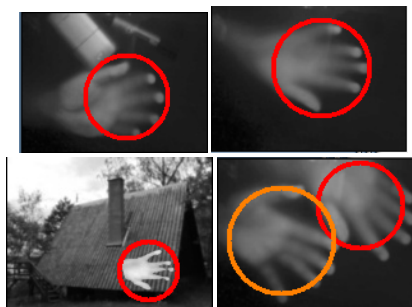

Fig 4. *Hand Recognition*

6. Finger, Blob and Hand Association

This section explicit the main ideas behind the purpose. After finding the Hand, the Blob and the fingers, they should be associated, and the blob TUIO would be modified to support the additional information that can be provided to the developer by the Tbeta.

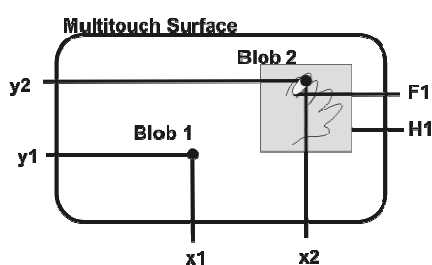**Fig 5**. *Finger, Hand and Blob Association*

Fig 6. *Finger, Hand and Blob Association Schematics on Surface*

An example of a TUIO string is:

/tuio/2Dobj set s i x y a X Y A m r

The new string would be:

/tuio/2Dobj set s i x y a X Y A m r FID xf yf HID xH yH

7. Tracking

Tracking algorithms need then to be implemented to all the entities found. One idea for fingers is the same of the one used for pedestrian tracking using an Extended Kalman Filter approach. For hands, some algorithms using Mean-Shift Tracking seems to be the most reasonable for achieving such task.

frame 39   frame 78   frame 118

Fig 7. *Pedestrian Tracking with EKF*

8. Stereo Vision Analysis

An additional/future functionality could be the extension of the algorithms to the stereo plane , providing recognition association and tracking on the 3D space.
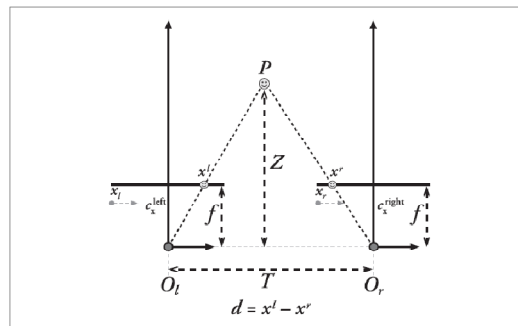
Fig 8. *Stereo Vision sample axes*

9. Conclusions

It seems that a plugin that could implement those functionalities on top of the Tbeta, could enhance and augment considerably the kind of applications the community is working right now. The implementation of the concepts established until the section 7, are the basis of the project purpose. The eight consists more of future work, and what could be done to enhance the system. The development of these techniques should take the 3 months established for the GSOC. After completion, it should be fully

documented and added to the Tbeta for the whole community to enjoy the functionality.

10. **Author Information**

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Academic and Industry Background: I am an undergraduate student on Electrical Engineering(emphasis on Control and Automation. Currently I am a researcher and developer on the Embedded Systems and Pervasive Computing Laboratory on the Universidade Federal de Campina Grande, on a Multitouch Project, in cooperation with the Instituto Nokia de Tecnologia (Nokia Institute of Technology), where my work is mainly conducted on computer vision, especially with hand, blob and finger recognition and association. I have worked for a computer manufacturer company customizing Linux Distributions for easing their usage for people that are not acquainted with Linux. And also, I am a member of the Brasil-VR team , the Latin American Champion and qualified for the Robocup Worldwide Championship in Graz, Austria 2009, on the Robocup Virtual Robots Rescue Simulation League. My main research interests are Robotics, Computer Vision, SLAM(Simultaneous Localization and Mapping), Probabilistic Robotics, etc.

Open source development experience: My open source experience is mostly from the work cited above. For the project proposal the main experience in my opinion is the one conducted in C++ for our code to the Robocup. Also, OpenCV experience for the development on the Multitouch Project. Have developed a python Open Source API for interacting Lego Mindstorms NXT with Nokia Linux OS based Devices. And also, a C++ platform for robots interaction with Wireless Networks.

Development Methodologies: The work is going to be conducted within 20

hours each week and continuous contact/ online meetings with the mentors. A project tracking technology is definitely going to be adopted. The project proposal consists on a research and development one, so some part of the time is going to be allocated to the first matter. The implementation will be done on the C++ Language, using the Linux Platform and the CodeBlocks IDE, as the implementation is going to be on the top of Tbeta, and there is a project from this IDE on the Tbeta repository. Also, the algorithms implementation is going to use the OpenCV library on the above mentioned language.

Project Proposal: The proposal is to provide a plugin for Tbeta that would allow the association between hand, blobs and fingers, as well as it tracking, augmenting the opportunities for applications that could make use of this additional information.

The reason for picking specific project:

The Reason for picking the specific project is that it is something that I am currently researching and working on, as well as these additions to Tbeta, would be really useful for my lab's application developers. And also, that would be an amazing opportunity to get even more involved to the nui community and give a small/although really wanted contribution for the enhancement of this wonderful application.

Activity level within the NUI Group Community:

Unfortunately I have not been as involved as I wanted with the NUI Group Community, however the GSOC 09 seems as a wordless opportunity for interacting and contributing with the community, especially with the "gurus", and developers related to the touchlib/tbeta community.

Time working multi-touch, natural user interfaces, HCI and related fields.

Specifically with multi-touch, I have been working for 6 months, but for HCI and related fields I have been working for more than 2, 5 years.

We also allow space for optional details the student sees fit.

Gladly , I am being fully supported by the lab, and by professors from my university, including technical and financial and comprehension support for being able to achieve the things proposed and even negotiating on the top of it for guaranteeing hopefully the acceptance to the GSOC 09, as a student mentored by the NUI Community.

11. **References**

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