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COMBINED ILLUMINATION METHOD FOR FINGER AND OBJECT TRACKING IN MULTI-TOUCH SYSTEMS

BY

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Abstract. With the advent of multi-touch technologies, several types of touch sensing devices have entered the mainstream phase and the research focus has shifted towards designing systems for the general public. While capacitive and resistive methods are employed in the creation of small factor devices – phones and tablets – the optical tracking systems carry the advantage of scalability, allowing the implementation of large, multi-user collaborative solutions. One of the solutions to improve touch sensing performance is found in the fusion of two or more illumination/tracking methods.

Key words: multi-touch; optical tracking; illumination fusion.

1. Introduction

One of the main advantages of optical multi-touch systems – along with the increased size of the touch area – is the possibility to recognize both fingers and objects (fiducials). However, most optical technologies are capable of performing finger touch recognition better than fiducial tracking and in the case of system optimization for object recognition, the finger tracking performance is severely lowered.

While improved software algorithms could allow a good recognition of

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both fingers and fiducials, the increased computational power is significant, the added complexity of the tracking software reducing the speed of the end-user applications. In addition, the adverse effects of environmental lighting on the multi-touch device will increase, since the software algorithms artificially increase luminosity and contrast.

One of the solutions to improve tracking performance is based on the fusion of two or more illumination/tracking methods. Several examples can be found in scientific literature and in the early work of the authors (Buxton, 2007; Hodges *et al*., 2007; Çetin *et al*., 2009; Crişan *et al*., 2009). Out of the four main optical illumination techniques (FTIR –Frustrated Total Internal Reflection, DI – Diffused Illumination, DSI – Diffused Surface Illumination, LLP – LASER Light Plane), FTIR and DI are the preferred methods for illumination fusion. However, while DI offers accurate object recognition at the expense of finger tracking, the FTIR method adds less value since object recognition cannot be achieved and finger tracking is similar in performance (Crişan *et al*., 2009; Han, 2005).

The research leading to this paper was focused on combining the DI method with the LLP technique. Laser based illumination offers the most accurate finger position recognition and, as mentioned earlier, DI offers good object identification. The fusion of these optical methods has its disadvantages related to difficult surface mapping and overlapping position data. However, several fiducial models are presented that can diminish the effects of uneven illumination offering an accurate detection of both finger position and object identification.

2. Object and Touch Detection in Optical Multi-Touch Devices

As mentioned in the introduction of this paper, several methods can be used to achieve object and touch detection in an optical sensing device. Combining different types of illumination allows the system to increase the tracking performance by separating finger and object touches while keeping the computational power to a minimum. This section will present the two methods chosen for the illumination fusion, emphasizing the optical–electrical design of an optical multi-touch system based on these technologies.

2.1. Laser Based Touch Tracking

One of the newest illumination and tracking methods for surface touches is the Laser Light Plane (LLP). As opposed to the other optical sensing techniques that employ several arrays of LEDs to generate infrared (IR) radiation, the LLP method uses commonly available laser diodes paired with line generating lenses. By placing several lasers in the corners of the multi-touch device a light plane is generated that will cover the whole active surface area. Depending on the size of the device, 2 to 8 lasers are commonly employed. While two lasers placed in opposed corners would still generate enough radiation to extend the light plane to the required dimensions, tracking becomes difficult due to the occlusion phenomena. Since the light plane can be blocked by placing a finger or an object there is a need for an illumination redundancy where even the hidden markers receive sufficient lighting in order to scatter the IR radiation towards the sensing element.

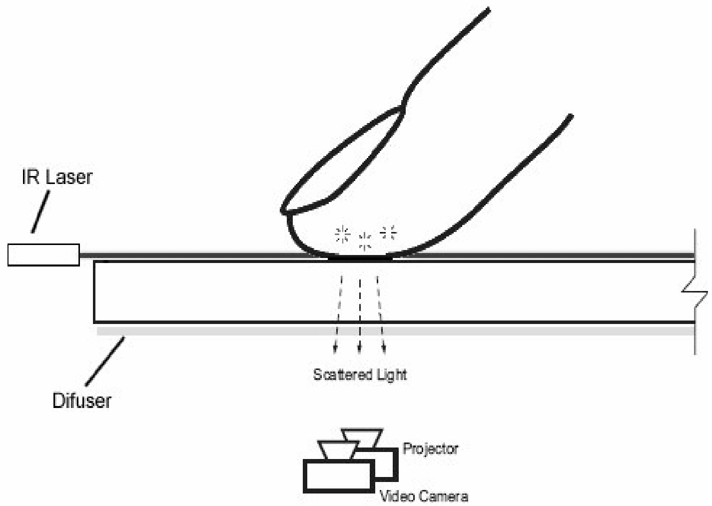

Fig. 1 – Laser Light Plane (LLP) – method overview (Çetin *et al*., 2009).

The method principle is shown in Fig. 1. The laser plane is 0.3…1 mm in thickness and is positioned above the surface at a distance varying from 0.5 to 2 mm. When a marker comes in contact with the laser plane radiation will scatter towards the CCD camera that acts as the radiation detector. The common Laser wavelengths used in this method are 780 nm and 850 nm for the increased availability of optical filters and greater environment immunity.

The LLP technique provides the best finger touch recognition of all the optical tracking methods due to the high contrast of touch blobs compared to the image background. This reduces the processing power and allows for smoother and faster tracking. However, passive fiducials can not be detected due to the nature of the illumination (light plane above the surface).

2.2. Object Recognition Using Diffused Illumination

The rear Diffused Illumination method is one of the simplest techniques employed in a multi-touch system while requiring even illumination across the surface in order to provide good tracking capabilities. The general schematic of this method is presented in Fig. 2.

The IR radiation is emitted towards the screen from below the touch surface. A diffuser is placed on top of the sensing area. When an object touches the surface it reflects more radiation than the diffuser or the objects in the background. The differences in detected light intensity are quantified with the use of a CCD camera after removing the IR-blocking filter.

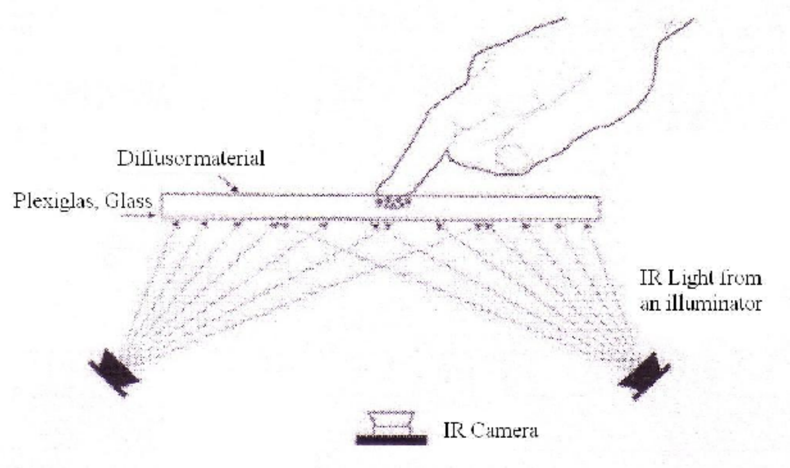

Fig. 2 – Diffused Illumination (DI) – general schematic (Çetin *et al*., 2009).

Depending on the diffuser, this method can also detect objects above the surface in close proximity and fiducials placed on the device. The diffuser material also doubles as a projection surface in the case of a video projector type system. This object detection feature adds significant depth the user experience, providing rich content and an improved user interface.

3. Illumination Fusion for Combined Touch Detection

The two methods presented in the first chapters can be combined in order to provide both good finger touch detection and object tracking accuracy. Both the Laser diodes and IR emitters must have the same wavelength in order that CCD camera be able to acquire the touch points.

A typical working scenario is depicted in Fig. 3. Several fingers are placed on the touch surface along with a fiducial object that has a distinctive marking inside its borders. When combining different types of illumination, the CCD camera will register multiple touch points due to the offset between the finger positions detected by each method. In optical multi-touch setups, a calibration algorithm is used in order to map the physical touch coordinates to the virtual image display on the screen. In the case of a dual illumination technique, the calibration algorithm was modified so that when registering combined blobs, the touch center is considered to belong to the higher intensity point, created by the laser plane. Since fiducials can not be directly detected by the LLP method, the system can automatically recognize an object by analysing the acquired image and identifying object borders. Even if the internal pattern of an object is not perceived by the camera when using just the Laser plane, the border is clearly visible if the fiducials are constructed so that the radiation is reflected downwards from the edges of the object. The modified tracking algorithm searches for rectangular shapes of higher pixel values (in terms of intensity) and classifies them as objects. Since the DI method can detect objects that have reflective patterns, only the markings belonging to a rectangular shape will be processed as external objects placed on the touch surface.

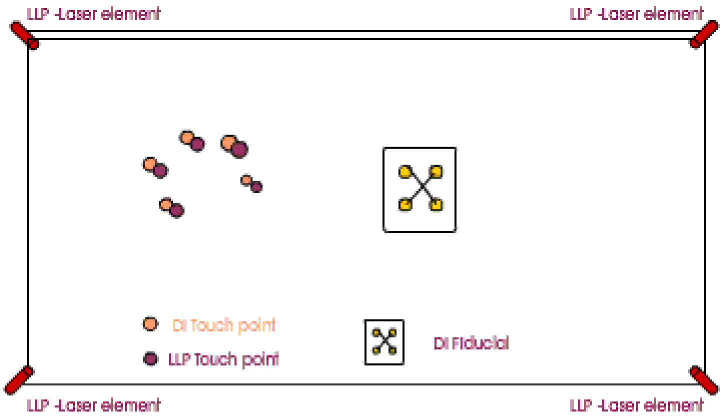

Fig. 3 – Touch markers in a DI/LLP illumination setup.

Using the modified calibration algorithm and the edge tracking of objects, the dual illumination system will detect both finger touches and objects placed on the surface without having coordination mapping problems or redundant image artifacts.

4. Conclusions

The research performed in this paper has shown that optical multi-touch systems are not optimized for finger and object recognition in the same time. By combining two illumination and tracking methods (Diffused Illumination and Laser Light Plane) tracking accuracy can be improved if the calibration and mapping algorithms are modified to process the resulting touch information. The results of this illumination fusion are encouraging and future research will focus on the creation of active fiducials that can be detected by the LLP method along with the passive objects tracked through the use of the DI illumination technique.

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METODĂ DE ILUMINARE COMBINATĂ PENTRU DETECŢIA ATINGERII DEGETELOR ŞI OBIECTELOR ÎN SISTEMELE TACTILE MULTI-PUNCT

(Rezumat)

Creşterea numărului de tehnologii de scanare tactilă multi-punct a permis apariţia unor sisteme senzoriale tactile orientate către piaţa de larg consum iar cercetările în domeniu au fost direcţionate spre implementarea de dispozitive destinate publicului larg. In timp ce metodele capacitive şi rezistive sunt folosite în construcţia dispozitivelor de dimensiuni reduse – telefoane mobile şi tablete – sistemele de detecţie optică tactilă au avantajul scalabilităţii, permiţând implementarea de soluţii colaborative multi-utilizator de dimensiuni mari. Una dintre soluţiile care pot îmbunătăţi performanţele detecţiei tactile se regăseşte în fuziunea a două sau mai multe metode de iluminare/detecţie.