ImpAct: Enabling Direct Touch and Manipulation for Surface Computing

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ABSTRACT
This paper explores direct touch and manipulation techniques for surface computing platforms using a special force feedback stylus named ImpAct(Immersive Haptic Augmentation for Direct Touch). Proposed haptic stylus can change its length when it is pushed against a display surface. Correspondingly, a virtual stem is rendered inside the display area so that user perceives the stylus immersed through to the digital space below the screen. We propose ImpAct as a tool to probe and manipulate digital objects in the shallow region beneath display surface. ImpAct creates a direct touch interface by providing kinesthetic haptic sensations along with continuous visual contact to digital objects below the screen surface.

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General terms: Design, Human Factors

Keywords: Direct Touch, Haptic Display, Touch Screen, Force feedback, 6-DoF Input, Simulated Projection Rendering

INTRODUCTION
Surface computing has become very popular and fairly ubiquitous. However, touch surfaces pose several limitations such as limited 2D interaction space, lack of physical feedback and other human factors(i.e. Fat finger problem). In real world, "touch" is being able to probe, feel and manipulate physical properties of the environment. However, current computer surfaces are far from such a touch interface.

ImpAct is a tool which enables users to interact with surfaces using their natural affordances. Usage of ImpAct can be analogous to manipulating an object inside a fish tank using a stick or a rod. As shown in Figure 1, ImpAct consist of a scalable stem, making it possible to change its effective length when it is pushed against a screen. Simultaneous to these changes in the length of the physical stylus, a virtual stylus is rendered inside the digital space below the screen surface aligned to the axis of the physical stylus(Simulated Projection Rendering). Movable stem of ImpAct is attached to a force feedback motor to provide haptic sensation to users when they interact with digital objects. From the perspective of user, it provides a visually continuous interface from the physical world to digital world.

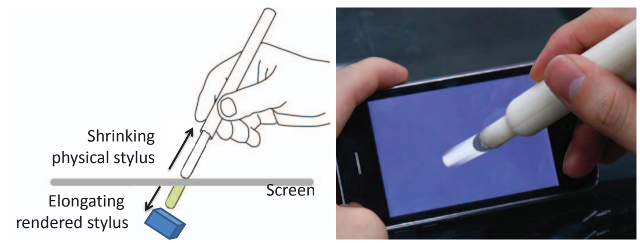

Figure 1: Left: Concept of ImpAct, shrinking physical stylus along with growing rendered stem. Right: Image of the prototype from a users perspective.

DESIGN AND IMPLEMENTATION
Design of ImpAct

Stem of ImpAct is created using two co-centric cylindrical shafts, one hollow and the other solid. User holds ImpAct by the outer tube(grip) allowing the inner shaft to be able to move within the grip. Which eventually makes the physical stylus to change its length. Back end of the moving shaft is internally attached to a DC(Direct Current) motor via a rack-pinion type transmission mechanism. This configuration is shown in Figure 2. DC motor can restrict the movement of the inner shaft, and also it can forcibly move the inner shaft through the gear mechanism giving kinesthetic feedback to user's hand. Friction between tip of ImpAct and display surface is sufficient to create a satisfying resultant force to make a kinesthetic haptic display.

ImpAct is equipped with an accelerometer and a magnetometer to calculate its orientation. These values along with the coordinates of the touch point on the surface is used to render the virtual stylus inside the screen. In this prototype, we assume a fixed viewing angle for graphics rendering. ImpAct does not require external tracking and also with its low power consumption (max 250mA, average 60mA (active), 5mA(idle), 5V), it is well suited for mobile applications. Current length change span of ImpAct is 5cm and maximum force excreted is 6N.

Interaction Space and Applications

Shallow-depth 3D interactions for surfaces are introduced in [2] and "above surface" [6, 3] and "below surface" [7] techniques were explored. With ImpAct, user has a visu-

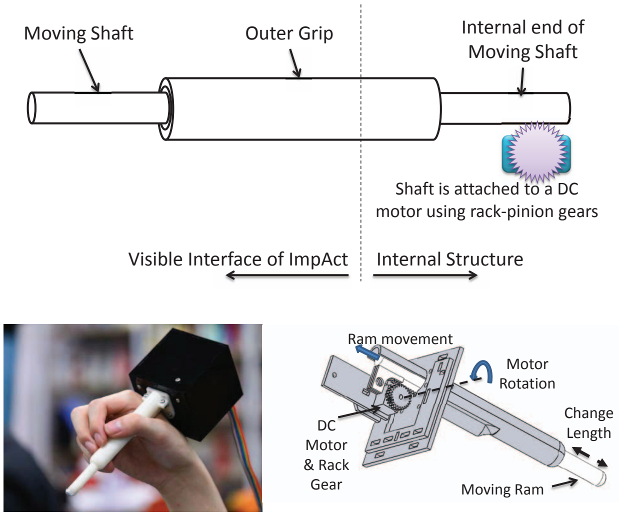

Figure 2: Top: Internal architecture of ImpAct. Bottom: Physical Prototype and CAD diagram.

ally continuous interface to digital space and a multidimensional interaction possibilities with haptic feedback, which is “through surface” interaction. Furthermore, unlike many existing haptic styluses[5, 4], ImpAct makes a spatially coincident haptic and visual interface. This is what we referred to as direct touch. Such interfaces can take the advantage of strong spatial relationships between touch and vision in human perception[1].

We developed different types of applications for ImpAct, including general UI controllers, probing of digital objects, manipulating objects and augmented reality applications. As shown in Figure 3, we created UI controllers which can use the z axis controls of ImpAct, probing applications to probe dynamic digital objects. For an example heart beat of an animal or vibrations of a vehicle. Figure 3 also shows a computer billiard game where ImpAct is used as the cue. ImpAct can used in the same way as the real billiard cue and haptic sensation of impacts between balls and the cue are provided.

Furthermore, we created an interactive mobile augmented reality application using ImpAct on iPhone. In this application, users can manipulate doors and windows in a room and puncher curtains (Japanese style paper curtains) of windows to see through to the other side of the curtain.

CONCLUSION AND FUTURE PERSPECTIVE

In this paper, we presented ImpAct and its capabilities as a HCI tool to enable direct touch and manipulation for surface computing. ImpAct combines visual and haptics stimulation sources in to same spatial coordinates providing a much effective and affective interface. It is capable of creating non trivial interaction possibilities and novel application scenarios for surfaces, specially with 3D applications. Furthermore, we are in the process of development of software applications and second prototype of hardware system. We have identified few limitations of the system, such as bulkiness of the prototype, requirement for a button on the device and need for head tracking to render perspectively correct graphics. We are addressing these issues in our next prototype.

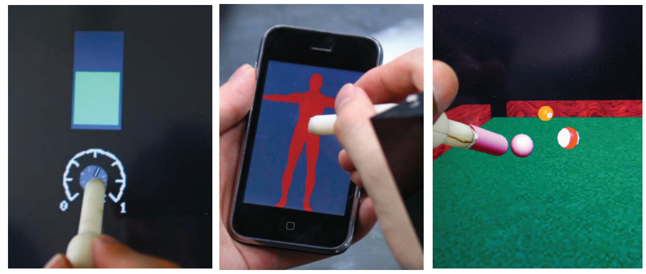

Figure 3: Sample applications of ImpAct. Left: Z axis controls to pick between layered widgets along z direction. Middle: Probing application to monitor heart beat of a CG human model. Right: ImpAct as cue to play billiard.

REFERENCES

1. Rob Gray and Hong Z. Tan. Dynamic and predictive links between touch and vision. *Experimental Brain Research*, 145(1):50–55, 2002.

2. Mark Hancock, Sheelagh Carpendale, and Andy Cockburn. Shallow-depth 3d interaction: design and evaluation of one-, two- and three-touch techniques. In *CHI ’07: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 1147–1156, New York, NY, USA, 2007. ACM.

3. Otmar Hilliges, Shahram Izadi, Andrew D. Wilson, Steve Hodges, Armando Garcia-Mendoza, and Andreas Butz. Interactions in the air: adding further depth to interactive tabletops. In *UIST ’09: Proceedings of the 22nd annual ACM symposium on User interface software and technology*, pages 139–148, New York, NY, USA, 2009. ACM.

4. Sho Kamuro, Kouta Minamizawa, Naoki Kawakami, and Susumu Tachi. Pen de touch. In *SIGGRAPH ’09: ACM SIGGRAPH 2009 Emerging Technologies*, pages 1–1, New York, NY, USA, 2009. ACM.

5. Ki-Uk Kyung and Jun-Young Lee. wubi-pen: windows graphical user interface interacting with haptic feedback stylus. In *SIGGRAPH ’08: ACM SIGGRAPH 2008 new tech demos*, pages 1–4, New York, NY, USA, 2008. ACM.

6. Jason L. Reisman, Philip L. Davidson, and Jefferson Y. Han. A screen-space formulation for 2d and 3d direct manipulation. In *UIST ’09: Proceedings of the 22nd annual ACM symposium on User interface software and technology*, pages 69–78, New York, NY, USA, 2009. ACM.

7. Daniel Wigdor, Darren Leigh, Clifton Forlines, Samuel Shipman, John Barnwell, Ravin Balakrishnan, and Chia Shen. Under the table interaction. In *UIST ’06: Proceedings of the 19th annual ACM symposium on User interface software and technology*, pages 259–268, New York, NY, USA, 2006. ACM.