

# Dual Mode IR Position and State Transfer for Tangible Tabletops

Ali Alavi

t2i Lab, Chalmers TH SE-41296,  
Gothenburg, Sweden

Andreas Kunz

ICVR, ETH Zurich, CH-8092,  
Zurich, Switzerland

Masanori Sugimoto

Interaction Technology Lab,  
University of Tokyo 113-8656, Tokyo, Japan

Morten Fjeld

t2i Lab, Chalmers TH SE-41296,  
Gothenburg, Sweden

## INTRODUCTION

The advent of widely available interactive tabletops, such as the MS Surface, has created high expectations among users for such systems. Today users expect a highly interactive experience when interacting at tabletops. Tangible objects emitting active infrared (IR) could be one possible way to provide a more interactive user experience with tabletops.

Most tangible devices for tabletops use infrared to send information about their position, orientation, and state. The method we propose can be realized as a tabletop system using a low-cost camera to detect position and a low-cost infrared (IR) receiver to detect the state of each device. Since two different receivers (camera and IR-receiver) are used simultaneously we call the method *dual mode*. Using this method, it is possible to use devices with a large variation of states simultaneously on a tabletop, thus having more interactive devices on the surface.

## OBJECTIVES

We want to improve the TUIs to achieve higher user satisfaction, since, based on user feedbacks from studies on tabletops such as QualiTrack[1], the level of interaction was not satisfying for a majority of users.

We observed that a significant improvement in perceived interactivity in tangible tabletops could be achieved by increasing the number of states a TUI can deliver. This enables system designers to offer more complex forms of interaction. For example, a high-end pressure-sensitive stylus may have up to 2048 pressure levels. To implement such a pressure sensitive stylus for systems like QualiTrack, the TUI needs to send 11 state bits. We could not reach this number of states on the initial system since the update rate would then drop dramatically.

Thus, our objective is to find a method which enables us to have a high number of states for TUI devices.

Mainly, we aim to design low-latency active devices, that is, devices with more states without reducing the high refresh rate of the system. Moreover, we are interested in a cost-effective solution.

## DESIGN CONSIDERATION

We are interested in having a relatively small number of tangible devices on the tabletop, each having a relatively high number of states. For example, considering the physical size of a table and the states required for a high-end pressure-sensitive stylus, we may simultaneously have five styli on the surface, each with 2048 possible states or pressure levels. To meet this requirement, we use two different receivers: a camera capable of detecting positions and an IR receiver capable of detecting the states of the devices. Concerning latency requirements, two terms are frequently employed: "update rate," which is the number of positions and states being updated per second, and "lag," which is the response time of the system to user input. We introduce a third term relevant to the method presented here: setup delay. This is the time from when a device becomes present in the tracked area until it is recognized.

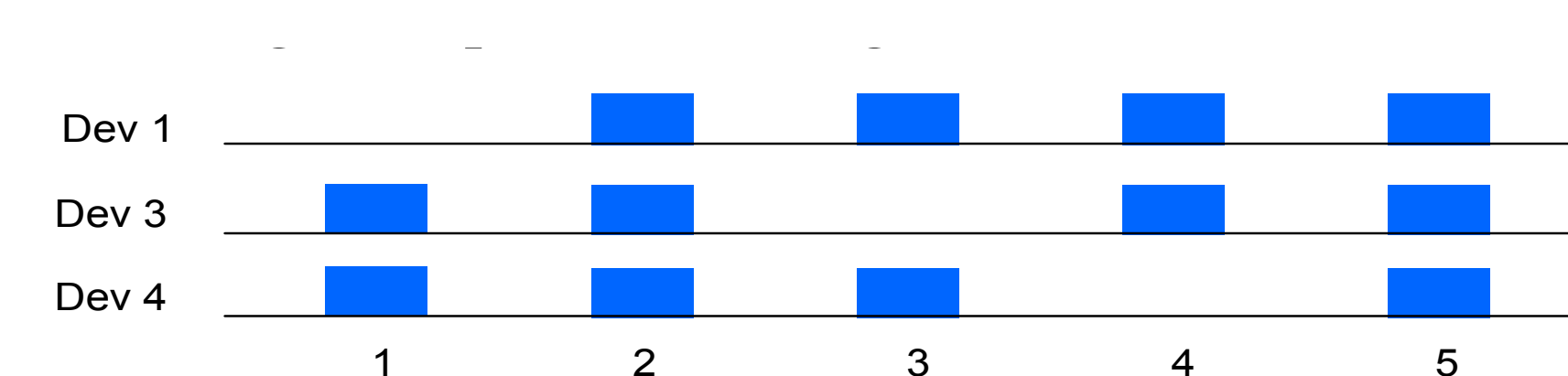
## DUAL MODE TRACKING

We suggest a distinct way to combine a low-cost camera for position detection and a low-cost IR receiver for state detection of each device, in what we call a dual mode approach.

We are interested in having a relatively small number of tangible devices on the tabletop, each having a relatively high number of states. For example, considering the physical size of a table and the states required for a high-end pressure-sensitive stylus, we may simultaneously have five styli on the surface, each with 2048 possible states or pressure levels.

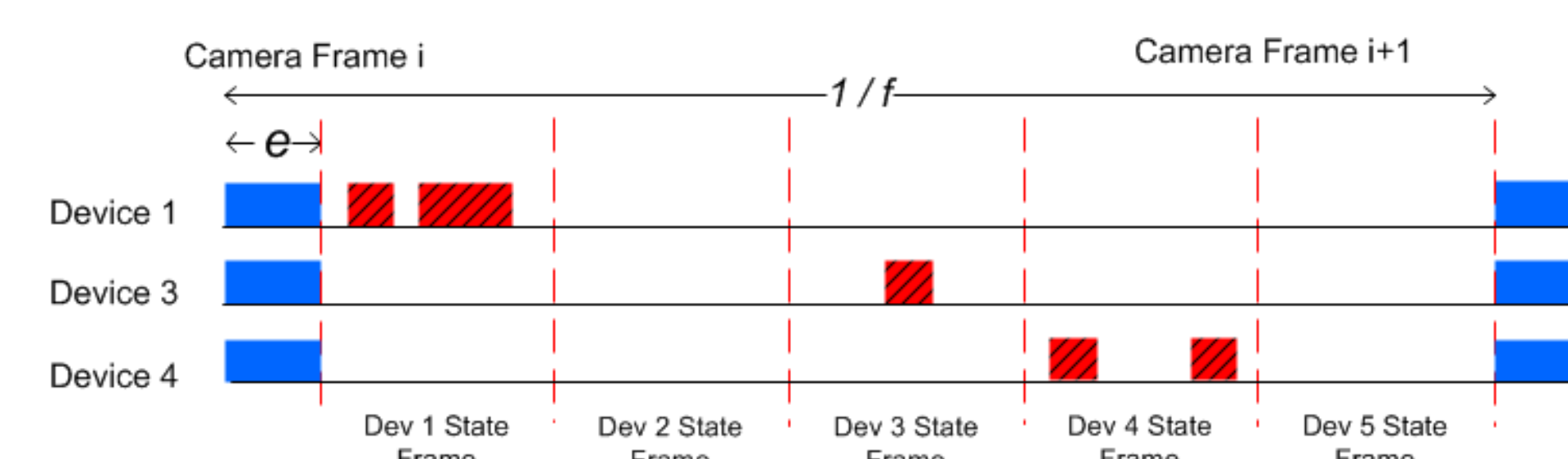
## TRACKING POSITION AND ORIENTATION

All devices emit IR light on each frame, except on their assigned time slot. Since the camera sees all the devices in every frame except one, the average update rate of the system equals  $f \cdot (M-1) / M$ , where  $f$ , is camera frame rate (Hz) and  $M > 1$  is the maximum number of devices simultaneously present on the table. Camera frames are indexed in cycles of  $M$  frames. Since newly placed devices wait for up to one cycle to start IR transmission, the maximum setup delay equals  $M/f$ . Thus, using the dual mode method, the number of devices does not reduce the system's update rate, nor does it increase its lag. Only the setup delay will be negatively affected. We can now unambiguously identify each device and its position. Device tracking uses a blob-tracking algorithm [3]. While we assume that a device has one LED source only, instrumenting a device with two or more LED sources and combining their positions can give device orientation [2].



## IDENTIFYING STATES

Each device transmits its state information using its IR LED between two synchronization signals, i.e. the speed of transmitting the state information is significantly higher than the speed of the camera. This is feasible since the state information is read by a simple IR receiver and not by the camera. The data rate of the sensor we employ is 22 kbps. The interval between two consecutive camera frames is further divided into  $M$  sub-frames. Within each sub-frame, only the corresponding device sends its state information. Hence, with IR receiver bit rate,  $R$ , camera exposure time,  $e$ , and  $f$  and  $M$  as defined above, the maximum number of state bits per device equals:  $R \cdot ((1/f - e)/M)$ . For example, with  $M$  set to 5,  $f$  at 60 Hz, and  $e$  at 10ms, each device can transmit 29 bits of state information, allowing more than half a billion states per device.

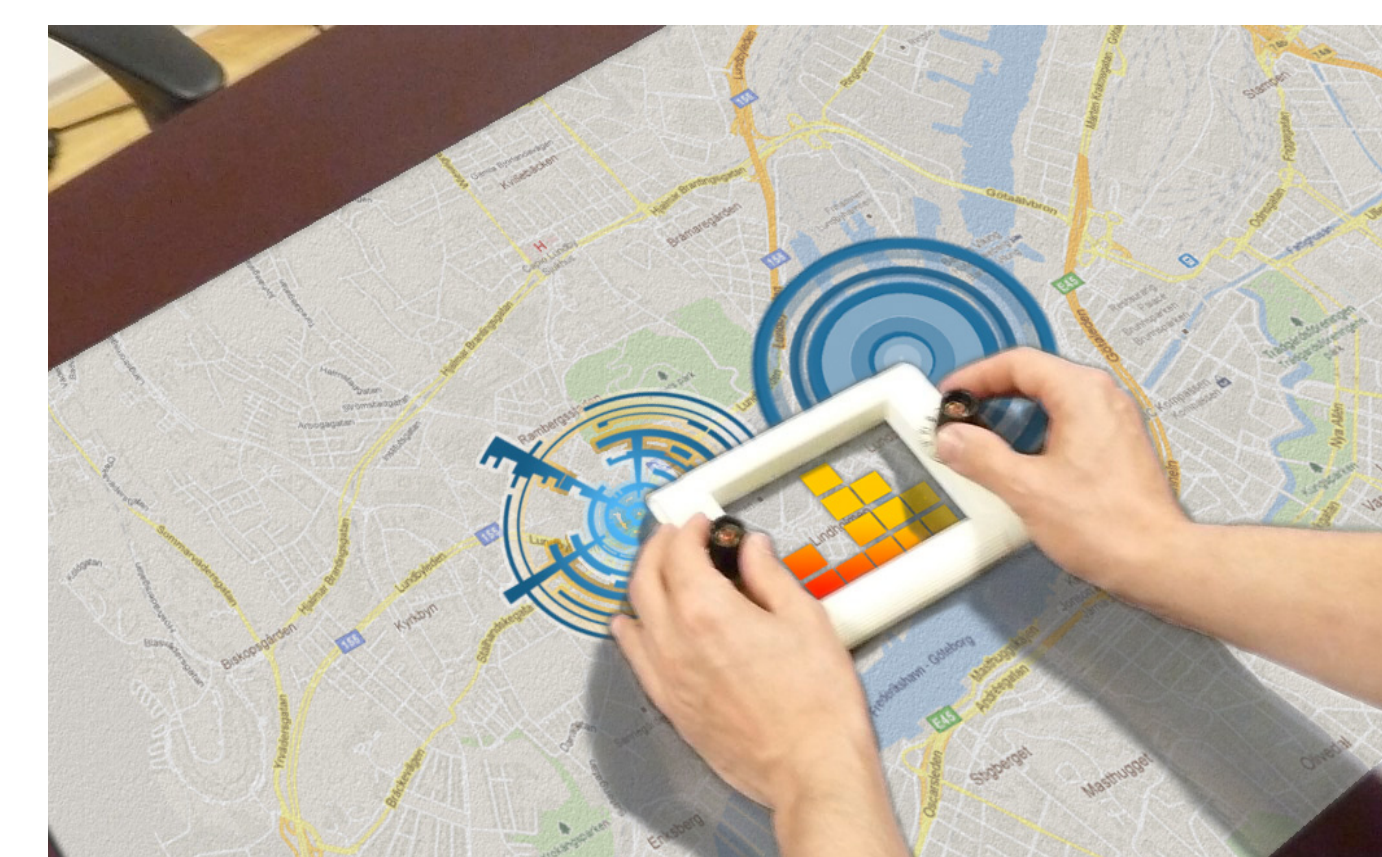
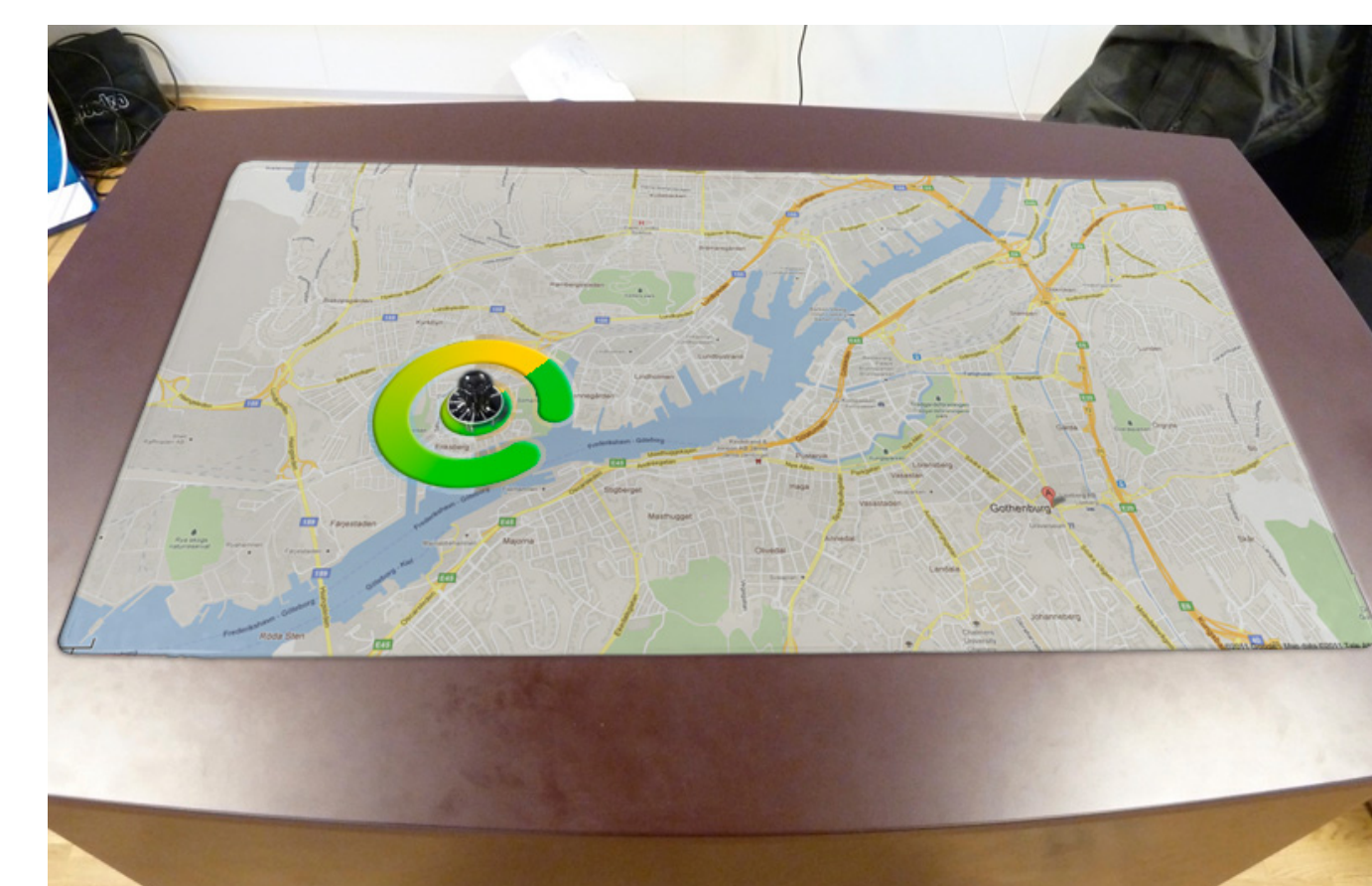
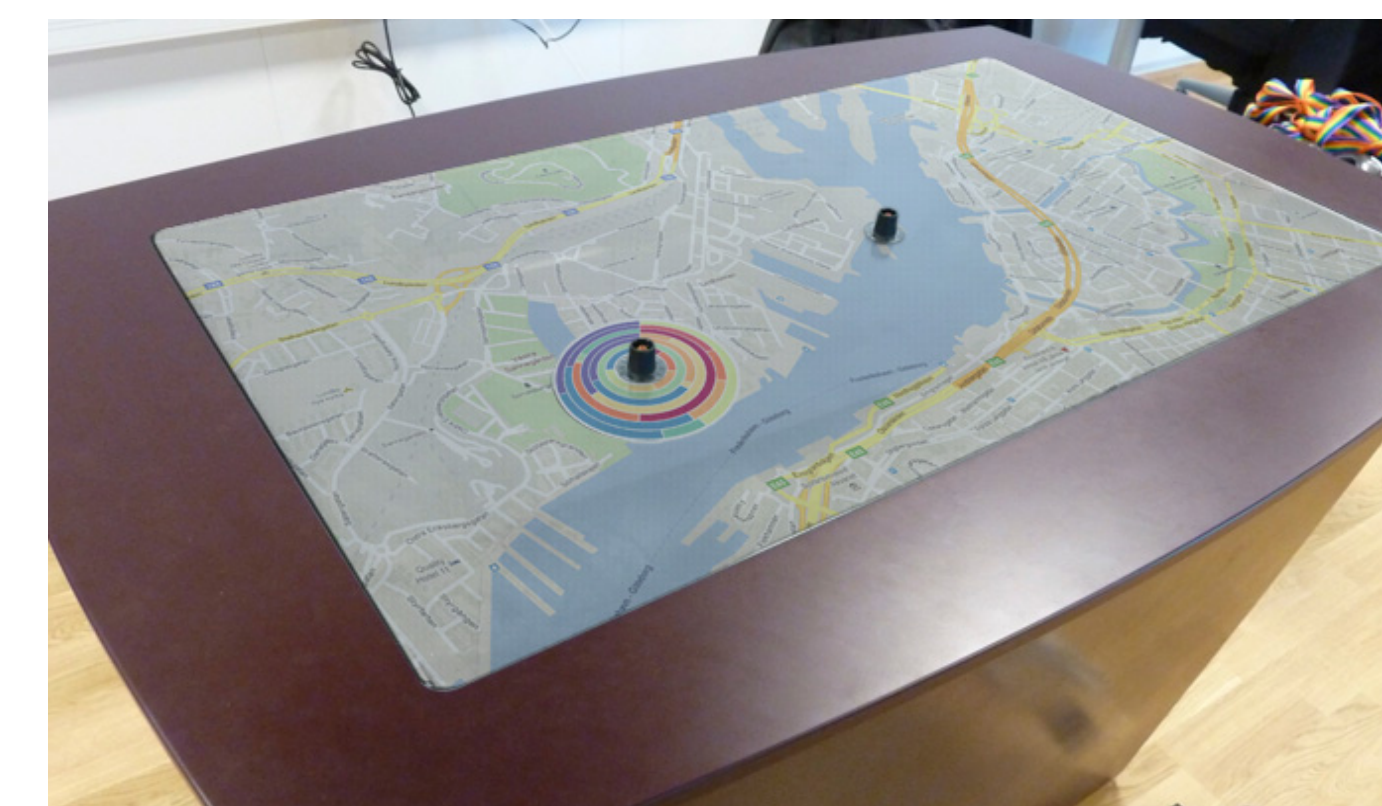


## APPLICATIONS

Though it is not in a finished state yet, we already have a table to work on improving it, namely a QualiTrack. Moreover, we have implemented an application for crisis management on it.



A tangible tabletop map-based application for TUI and pen-based interaction with Google Maps.



Multi-state device on existing tabletop system showing tangible continuous parameter control for values such as time, radiation level, or population (top and center); selection frame with two-handed continuous control of radar visualizations or mode selectors (bottom). (Simulated images)

## CURRENT STATUS AND FUTURE WORKS

We evaluated the feasibility of the proposed method by implementing its essential subsystems. Particularly, we implemented the IR receiver and changed the QualiTrack TUIs to send state information using our dual mode method. We also investigated whether the battery operated TUIs allow us to send signals powerful enough to be detected by the IR receiver, considering the distance between the TUIs and the sensor. Our findings show that it is feasible to implement a tabletop using our new method. A next step in this project will be to implement a complete tabletop using the method presented here.

## REFERENCES

- Hofer, R., Nescher, T., Kunz, A. (2009): QualiTrack: Highspeed TUI Tracking for Tabletop Applications, *Proc. INTERACT 2009*, Springer.
- Hofer, R. (2011): Tracking technologies for interactive tabletop surfaces, PhD Thesis, *ETH Zurich*.
- Schöning, J., Hook, J., Bartindale, T., Schmidt, D., Oliver, P., Echtler, F., Motamedi, N., Brandl, P., Zadow, U. (2010): *Building Interactive Multi-touch Surfaces, Tabletops - Horizontal Interactive Displays*, Springer.

CHALMERS

ETH

Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zurich

THE UNIVERSITY OF TOKYO