# Towards Multi-Touch Map Interaction on Tabletops: State of the Art and Design Recommendations

F. Klompmaker[1] and R. Ajaj[2]

[1]University of Paderborn, C-LAB, Paderborn, Germany
[2]LIMSI-CNRS and University of Paris-Sud 11, Orsay, France

**Abstract**

*Since smartphones like the IPhone and larger setups like Microsoft's Surface appeared on the market, the use of multi-touch interaction techniques is wide spread. Multi-touch allows intuitive, easy and fast interaction in principle but highly depends on the application type used. In this paper we present a brief state of the art report in the area of multi-touch and tangible map interaction on tabletops. We figured out design recommendations that we used for our evaluation prototype called MTMap.*

Categories and Subject Descriptors (according to ACM CCS): I.3.6 [COMPUTER GRAPHICS]: Methodology and Techniques—Interaction techniques

## 1. Introduction

Multi-touch interaction techniques highly depend on the application-type and -area. Since many large multi-touch setups are technically driven these days and predominantly show what's technically feasible, design guidelines for user interfaces and interaction styles are missing. There has been some research done in the area of interaction techniques using one or multiple fingers or even the whole hand [WB03]. Also comparisons between 2D and 3D user interfaces for multi-touch can be found [MCG09] and the quality of such interactions has been analyzed (e.g. the speed in [HCC07]). The downside is that these studies do not distinguish between different use cases. Our goal is to have a closer look at multi-touch map interaction suitable for tabletop setups in order to figure out design recommendations. Tabletop setups do not only allow multi-touch but also tangible interaction through arbitrary objects placed on the table. Further on they allow for multi-user interaction.
Since many map based tasks are collaborative ones (imagine town planning or disaster controll management) we think that tabletop setups are most suitable here. They enable an easier understanding of spatial relations when using appropriate information visualization [MK06] and fast as well as precise interaction when using tangibles [TKR*08]. Especially in time-critical collaborative situations table setups enable face-to-face interactions between the participants and fast understanding of the big picture since everyone can see who is doing what.
This paper will give a brief state of the art report on related research topics followed by some design recommendations we used to build our prototype application called MTMap. This prototype will serve as our user study setup to figure out the correctness of our design recommendations and the quality of applied interaction techniques.

## 2. State of the Art

Even though there's not much research done in the field of multi-touch map interaction on tabletop setups, there are many findings from related research areas like virtual reality, information visualization and HCI in general. Ajaj et al. [AVJ09] compared different 3D map interactions in a user study in order to analyze completion times and user preferences in navigation tasks. They found out that users prefer a fixed position of the virtual camera and a moveable map instead. Especially in multi-user applications this reduces the unfairness of different user positions when using a single table as display. Nevertheless a single view on a map may cause disorientation while a second view that is synchronized and miniaturized facilitates users in building shared mental models [Ese09]. However one single miniature view would increase unfairness again because of the different user positions around the table.

Oulasvirta et al. [OEN09] present some major advantages of using 3D maps for information visualization. They state that 3D maps especially allow for an easier creation of a mental model of the real world. Further on they also recommend an additional 2D view. We therefore decided to design our prototype application this way even though 3D visualization has some drawbacks like occlusion, hidden surfaces (see [TSWS05]) and different perception at different user positions.

## 3. Design Recommendations and Prototype

Here we describe some recommendations for the design of map based multi-touch applications running on a tabletop setup and enabling multi-user interaction. We used these as a guideline for building our prototype application called MTMap.

A big problem for multi-touch systems is the handling of multiple finger touches from different users at the same time since most multi-touch installations are not able to differentiate between users. Therefore a software-side analysis and estimation has to be done to decide which finger belongs to which user. To not confuse the system (and also the remaining users) the maximum number of users should be limited for these kind of applications. Tables ideally allow a collaboration of four users located on the table sides. This number depends on the table size of course. The map should be rotatable and translatable by every user whilst coordination of these interactions has to be done verbally amongst them. We recommend a simple finger interaction using one (translation) and two fingers (zoom) because these multi-touch interaction techniques are well-known and accepted (cf. [HCV*06]). Further on we argue that using 3D maps with limited depth allows for a better overview, spatial understanding and faster building of mental models needed for navigation or organizing tasks. We think that 3D views are necessary to get a better overview of the area of interest (e.g. buildings in a city or elevations in the countryside). Limited depth means in this case that users are only allowed to rotate around the x- and z- axis (the tabletop defines the x-z plane) a few degrees since this minimizes occlusions (cf. [TSWS05]). All rotations should be controllable via tangible objects, e.g. flat cylinders that have to be rotated. This allows a very precise interaction and prevents from accidentally triggered rotations with the finger.

An additional world in miniature (WIM) view is to be rendered on every side of the table - so there is one for every user. It should be minimizable in order to get as much space for the 3D view as possible. We think that this setup is the fairest solution for all users and it allows everyone to get an overview of the big picture. Addressing different 3D perceptions at different user positions we followed the recommendation of Hancock et al. [HNGC09] and applied parallel projection for rendering. Tangible objects as real world representatives (e.g. buildings or vehicles) could be used to control these in real-world design or organization tasks.

## 4. Conclusion

We introduced some design recommendations for map interactions on multi-touch tabletops. These are used to design our early prototype application that is now going to be used for a larger user study to find out the correctness of the recommendations described and to evaluate the quality of interaction in special. Evaluation parameters we especially address are interaction speed and precision, the cognitive load of the users, fairness of user positions and collaboration between the users.

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