

# Considering Reach in Tangible and Table Top Design

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## Abstract

Reach heavily impacts all aspects of designing for tangible and tabletop user interfaces. It dictates the input space available to each user and heavily shapes how that space is used. Despite its impact to date tangible, table top, and user interface design have all largely overlooked reach as a design constraint. As a result advancing the state of the art for tangible and table top designs requires rethinking existing designs to consider the repercussions of reach, and starting to formally consider reach as part of our designs process. Designing in consideration of reach will allow for more usable tables, applications supporting diverse environments, and user interfaces which are optimally scaled to their current set of users.

## 1. Introduction

Industrial designers already blend aesthetic, functional and ergonomic concerns in the design of conventional tables and desks. Armed with anthropometric data for humans they are able to ensure their designs remain aesthetically attractive and functional while still being usable by a large segment of the overall population. In fact commercially mass produced furniture is designed to be usable by 95% of the overall population. As developers of horizontal interactive human computer systems we inherit from conventional tables and desktops a mature set of aesthetic, functional, and ergonomic expectations. It is our responsibility as designers to meet these expectations while ensuring that any new systems we develop remain usable by as broad a cross section of the population as possible.

Existing anthropometric tools allow designers to gauge the impact on their systems of a wide array of decisions; such as table size, shape, layout and user distribution. One particularly powerful tool is mathematical models of reach. Understanding reach provides a great deal of high level information about the ecology of horizontal interactive systems.

Models of reach help answer user interface questions such as “where can user interface elements be placed so that they will be reachable by a particular user?”, “what areas are users able to reach in an on table display?” or “How can we structure this entire application to run on equally well on two tables of differing size or shape?”.

Beyond the mechanical constraints, reach appears to partially underlie the previously observed psychophysical phenomenon of table partitioning and territoriality.

## 2. Understanding Reach

The dynamic reach envelope (or Kinetosphere) [1] describes where the user is able to reach. This volume of reachable space dictates the maximum space available for input to physically interactive user interfaces. Unless the user moves around the table during the interaction all tangible or gestural interactions, either on the plane of the table or in the air above it, are constrained within the dynamic reach envelope.

While reach as a question of posture, or potential position within the arms possible range of motion, is extremely complicated it has fortunately been well studied in the field of anthropometry and intuitive models exist to define its envelope; maximum reach. The most common anthropometric model for maximum comfortable reach (i.e. the Zone of Comfortable Reach or ZCR) is a spherical shell centered on each shoulder, the radius of which is the acromion (shoulder) to grip (center of palm) distance [1]. On table reach is determined by intersecting these two spheres with the plane of the table.

Industrial designers already use this model of ZCR as a powerful yet simple tool for mathematically predicting an individual’s maximum comfortable reach from a set of anthropometric specifications.

### 2.1. An Informal Measure of Reach

To begin our own investigations into reach, after a literature review, several informal experiments were conducted. These experiments were conducted in order to develop intuition about on table reach and to confirm our understanding of structural anthropometry’s existing tools. For our informal studies of maximum reach subjects were instructed to place tiles as far away from themselves as possible under various conditions. White tiles were placed with their left hand and black tiles with their right.

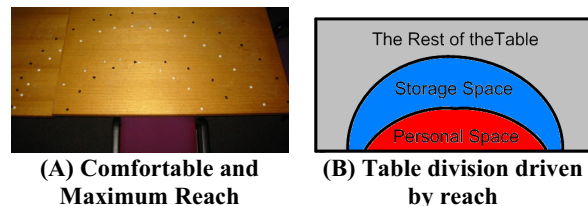


Figure 1 Seated Table Reach

A representative sample of our initial results for both maximum (outer) and maximum comfortable (inner)

reach for a single seated individual is shown in Figure 1. As predicted by the simple model of ZCR our informal results showed on table reach, the union of the left and right handed reachable spaces, to be roughly elliptical.

## 2.2 Seated vs. Standing Reach

Next an informal study comparing the seated and standing reach for an individual (Figure 2) was conducted. Standing reach was also seen to conform to conventional anthropometric models of ZCR, which look at the horizontal distance of the shoulder to the reach surface. Standing merely scales the reach envelope, and as a result most observations made about the impact of either standing or seated reach may be generalized.

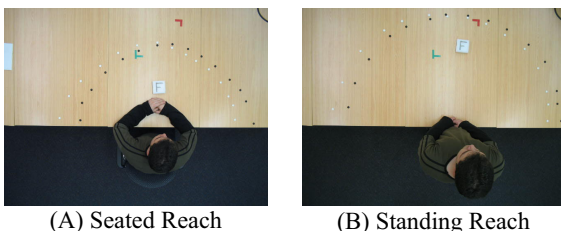


Figure 2 Formal Reach; both Seated and Standing

## 2.3 Reach divides the table into 3 regions

Obviously reach divides the table both physically and psychologically into two areas, the area that the user can reach and the rest of the table. The reachable area has been observed to further segment (Figure 1B); with space near the body being used for working space and space farther from the user being used for storage [2].

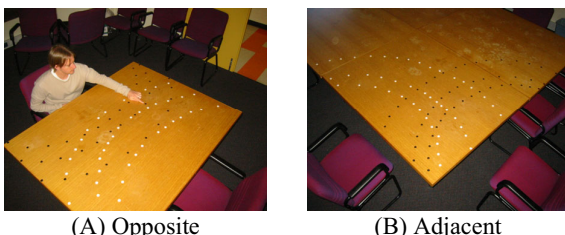


Figure 3 Regions of opposing and adjacent reach

## 2.4 Ownership and Territoriality

Multi-user collaborative contexts bring new regional concepts to the table; ownership and territoriality. From a user's perspective collaborative systems divide into some combination of personal and group storage and interaction spaces. The authors believe that grasp dictates the available group interaction and storage spaces and that the envelopes of reach form the boundaries for those spaces. Examples of areas of overlapping comfortable, formal, and maximum reach for opposing and adjacent users are shown in Figure 3 A, and B. The authors are currently investigating how grasp predicts the sort of previously reported [2-4] territoriality, in on table collaborative environments.

## 2.5 Reach dictates the maximum user interface size

While advances in technology are making large high resolution display surfaces with increasingly arbitrarily shapes possible [5, 6] it is important to realize that the increase is only in the raw display size. The area of display space available for any kind of UI interaction; be it gestural, tangible, tactile, or AR, is limited by where the user can reach. So while total possible display space available to system designers may continue to increase the dynamic reach envelope of their systems users, and thus the available input space for their system, is in fact fixed in size. Initially studying reach's impact on tabletop user interface design is critically important as it will help determine what this fixed UI volume is for any given user. An essential first step before, as a development community, we can seriously begin designing any sort of horizontal interactive human-computer systems.

## 3. Where to go from here

As developers push to enable the user to be able to do more in a fixed space a phenomenon of "application pressure" will force the refinement of interaction techniques. This process will be analogous to the refinement of the desktop user interface paradigm over the last twenty years as it was pushed to marshal an ever greater number of increasingly complex applications within the fixed screen real-estate.

The authors feel that leveraging anthropometric models currently represents a powerful way to advance the state of the art in horizontal interactive human-computer systems. Understanding reach allows researchers and designers to produce more usable tables, applications spanning multiple smart table designs, and user interfaces which optimally scaled to their current set of users. Several initially apparent reasons why reach is an important consideration in interactive design have been presented. The authors are currently following up on what they feel are important initial observations from their informal studies and are in the process of more thoroughly and rigorously testing their observations.

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