Interaction on Non-Planar Devices

Marcel Lahaye – CTHCI 2018

RWTH AACHEN UNIVERSITY


SAMSUNG
63% 4:27 PM
4:27 PM
Thu, January 21
Google
Say "Ok Google"
Email
Camera
Gallery
Play Store
Google
Phone
Contacts
Messages
Internet
Apps

Image from LG Flex 2 Product Page

The Flex device series from LG presents curved devices

http://www.lg.com/us/cell-phones/lg-AS995-Platinum-Silver-g-flex-2

U.S. Patent Nov. 22, 2016 Sheet 8 of 18 US 9,504,170 B2

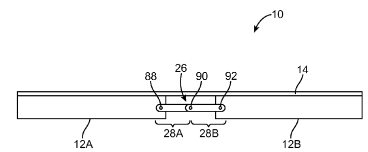


FIG. 10

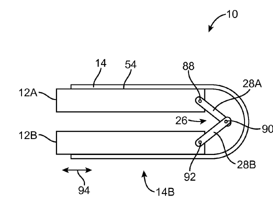


FIG. 11

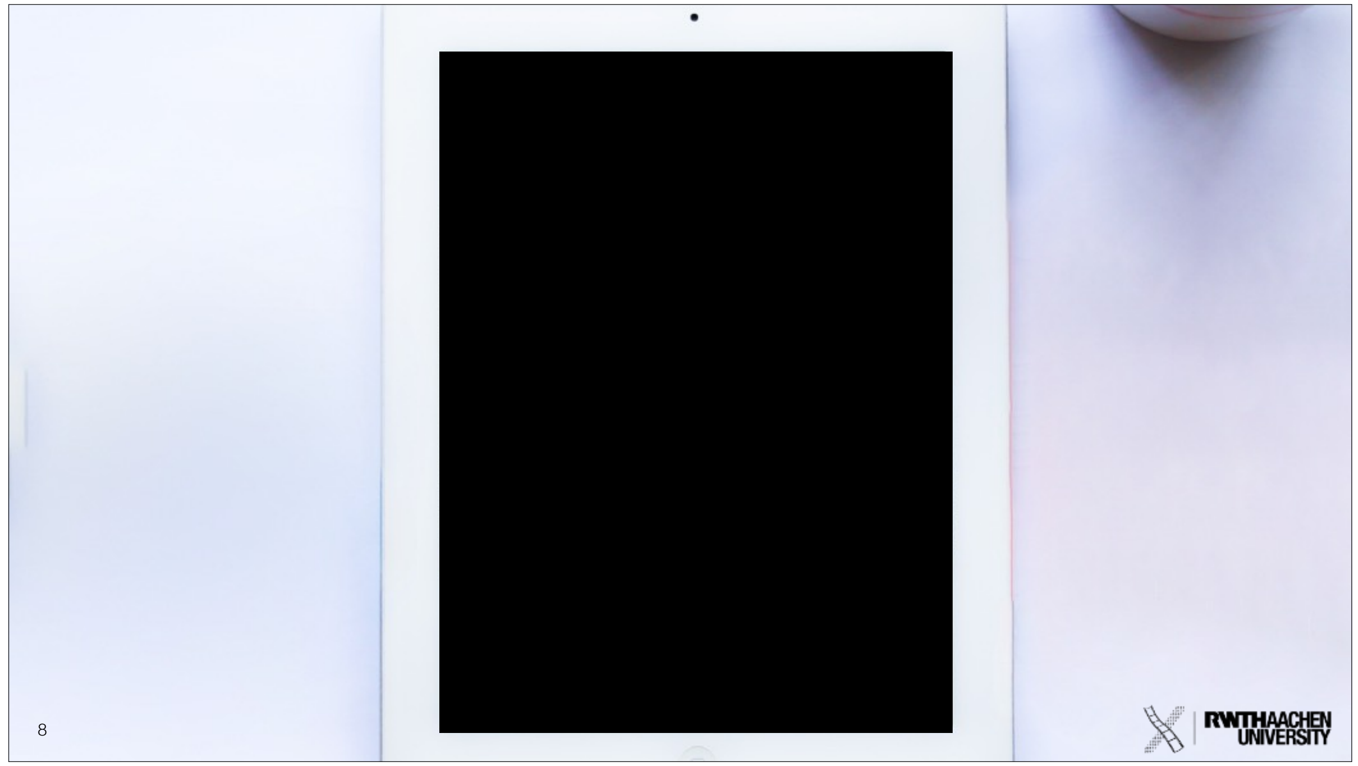
Image from U.S. Patent No. 9,504,170

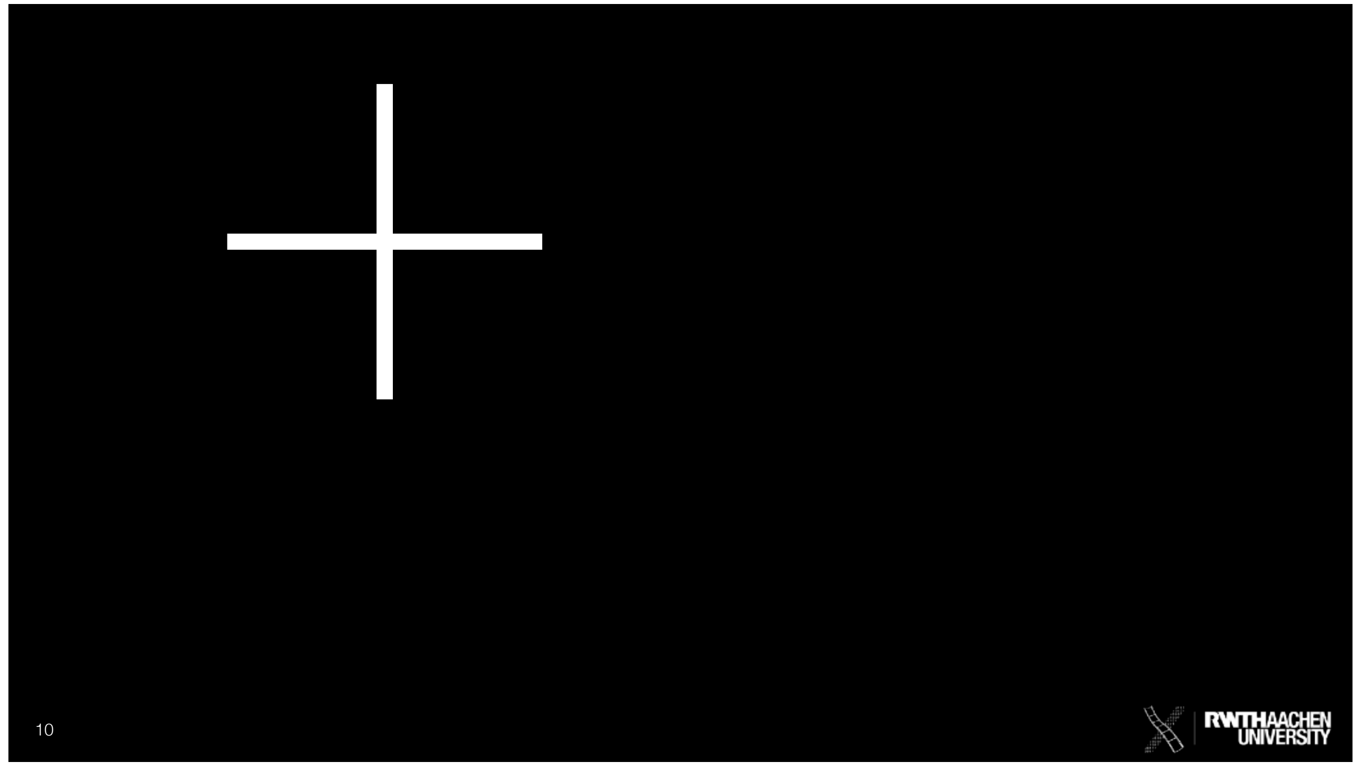
Companies like Apple are handing in patents for non planar devices

However, most of our everyday device still have a flat interaction and presentation surface.

Why would we use non-planar devices?

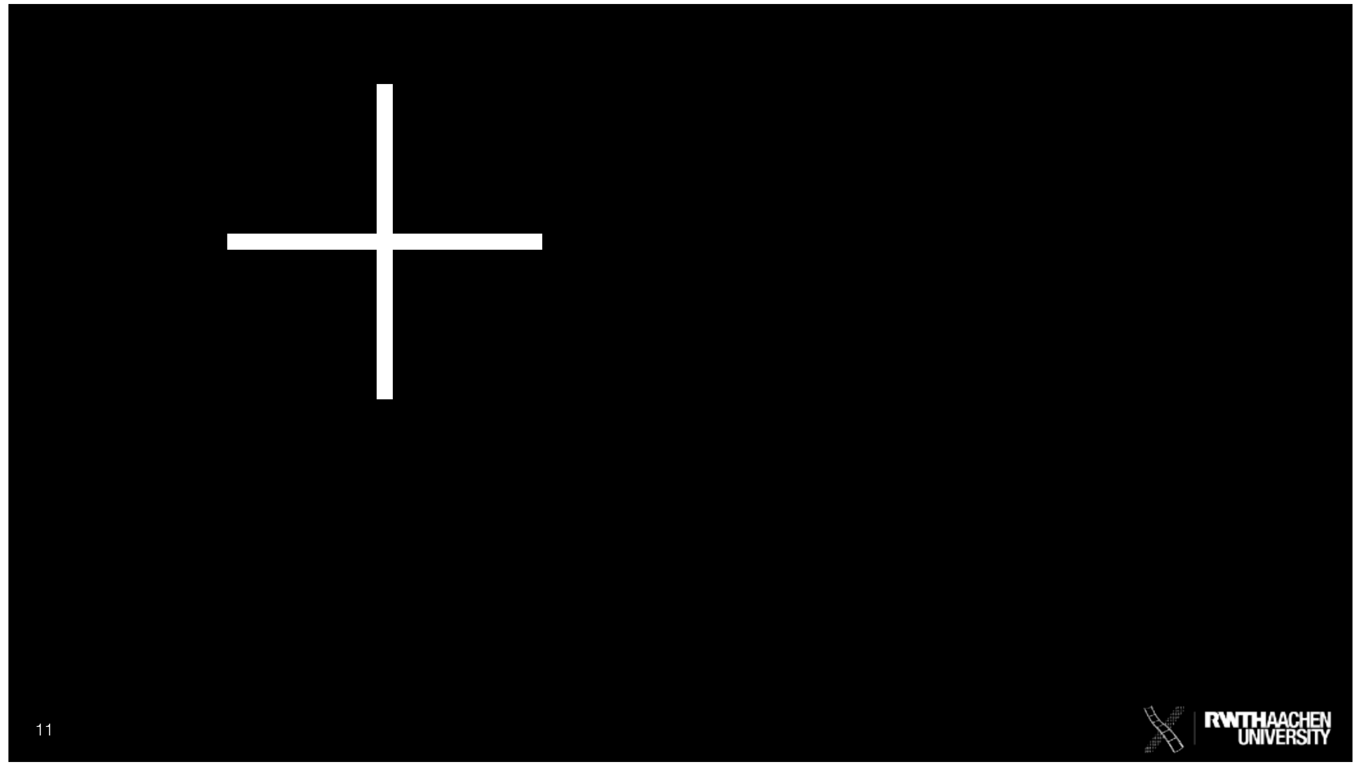
Influences touch accuracy





Touch target where the user is asked to press the center of the target

The contact area where the user touched is sensed by the system.



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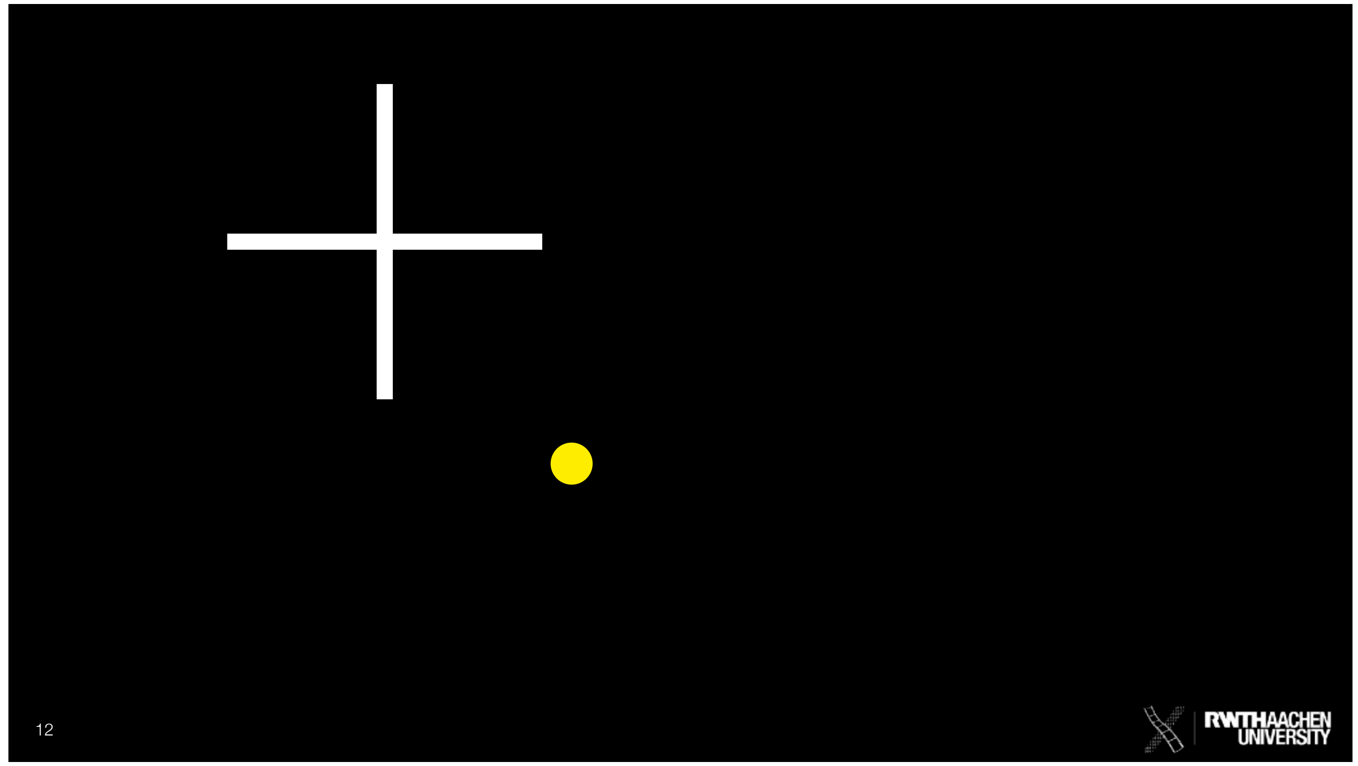
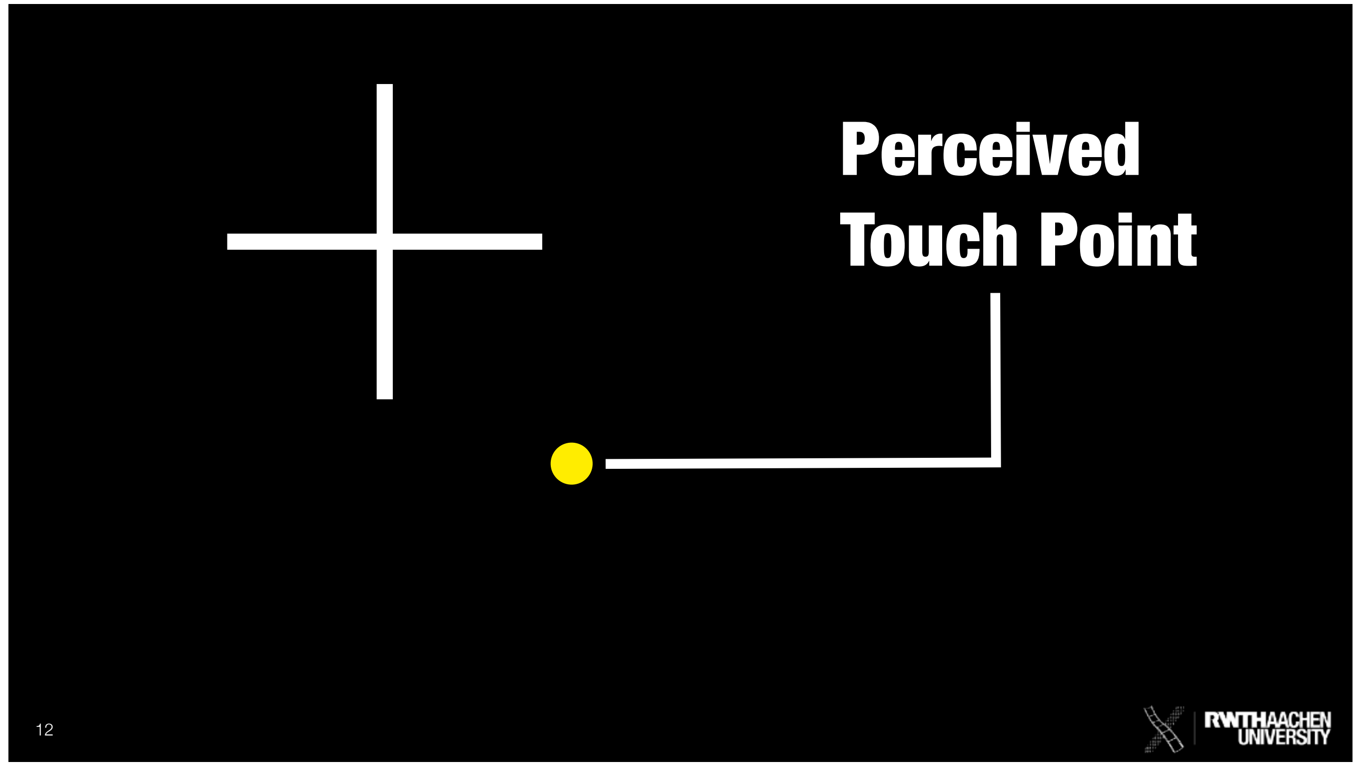


The center of the contact area is used as the perceived touch point. However, most current systems are adjusting the touch point because research has shown that the center of the contact area might not be the point where the user perceived that she has touched. (see Understanding Touch by Holz and Baudisch from CHI'11 http://doi.org/10.1145/1978942.1979308)



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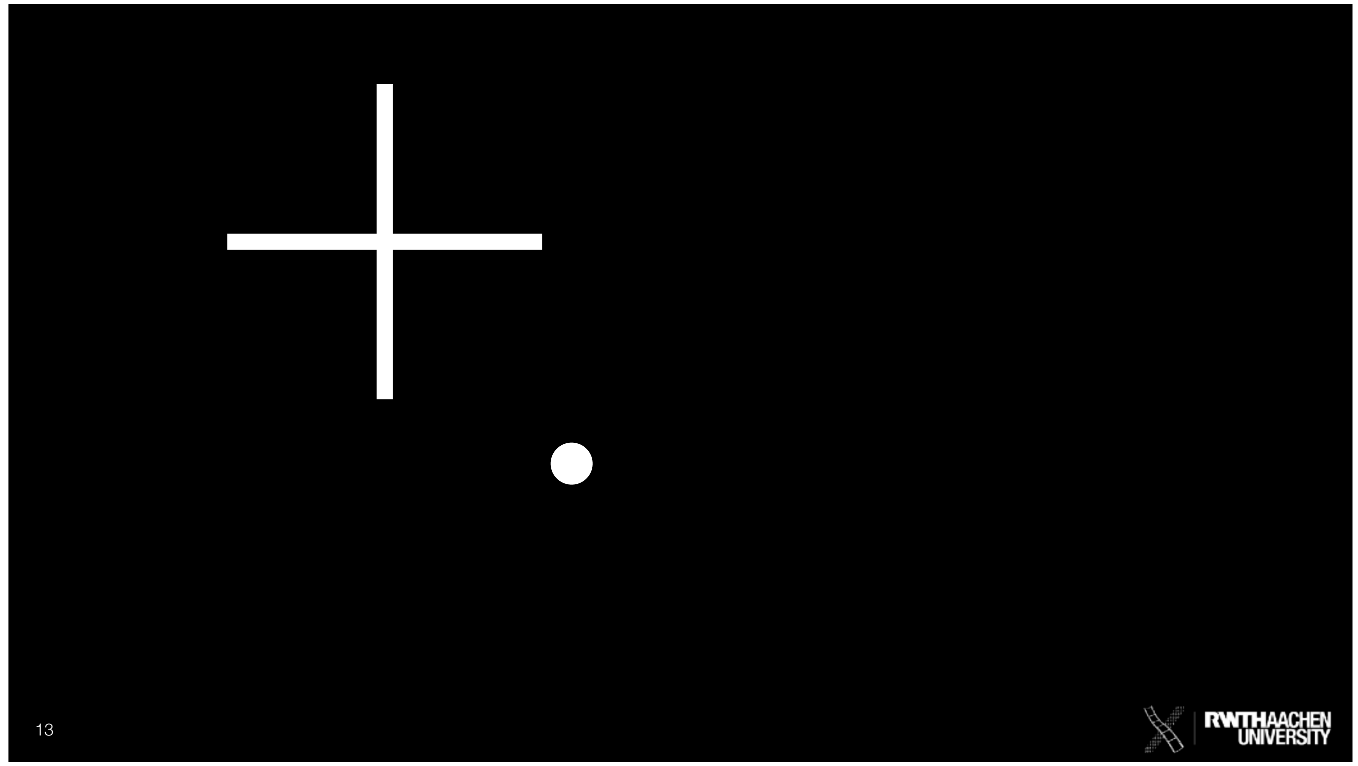
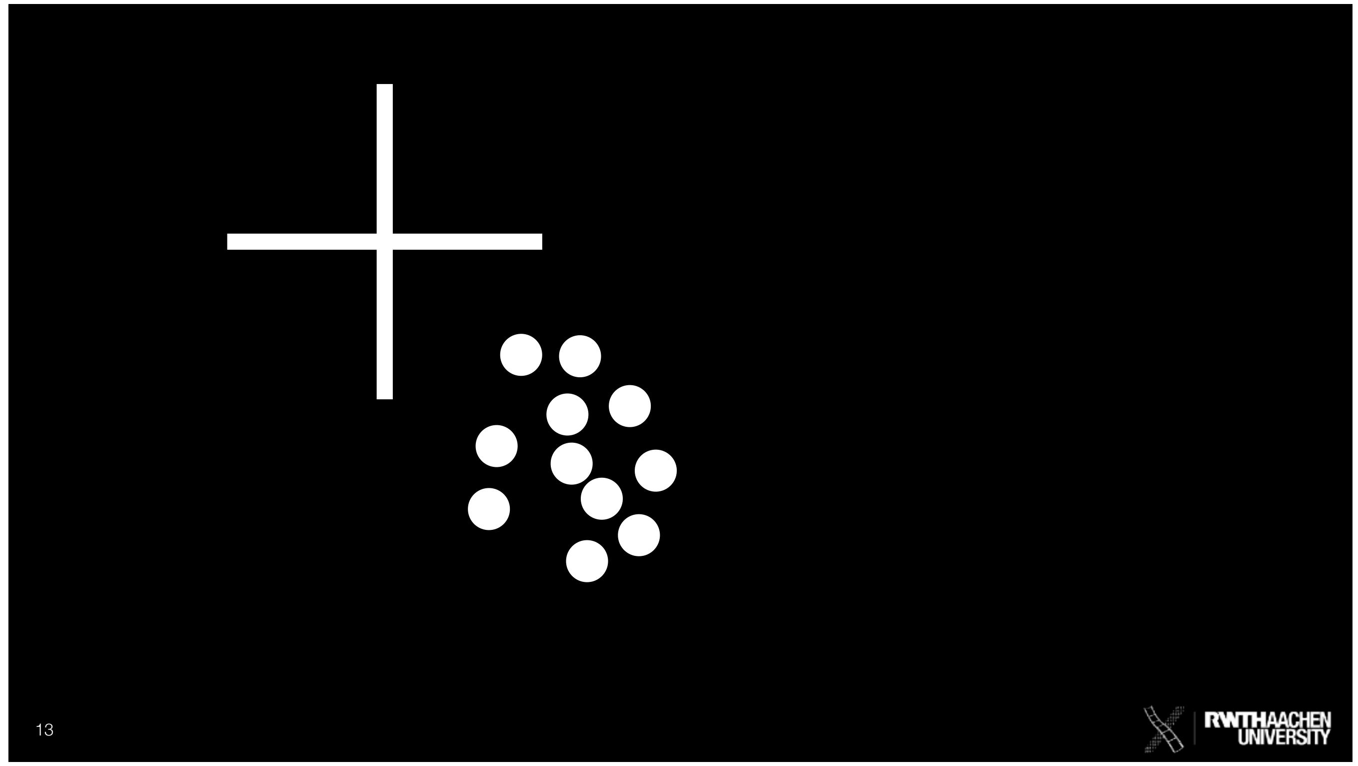


More touch points are gathered by multiple users which then generates this point cloud.



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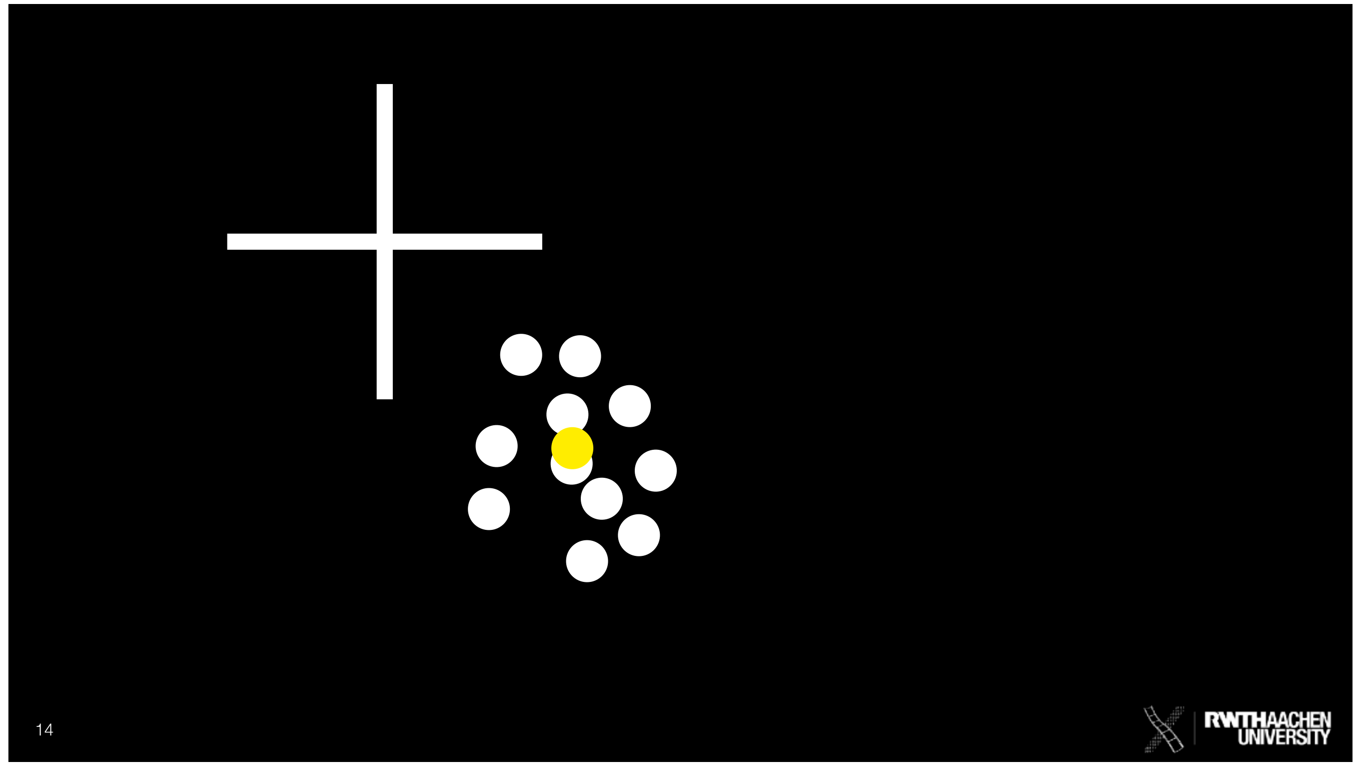
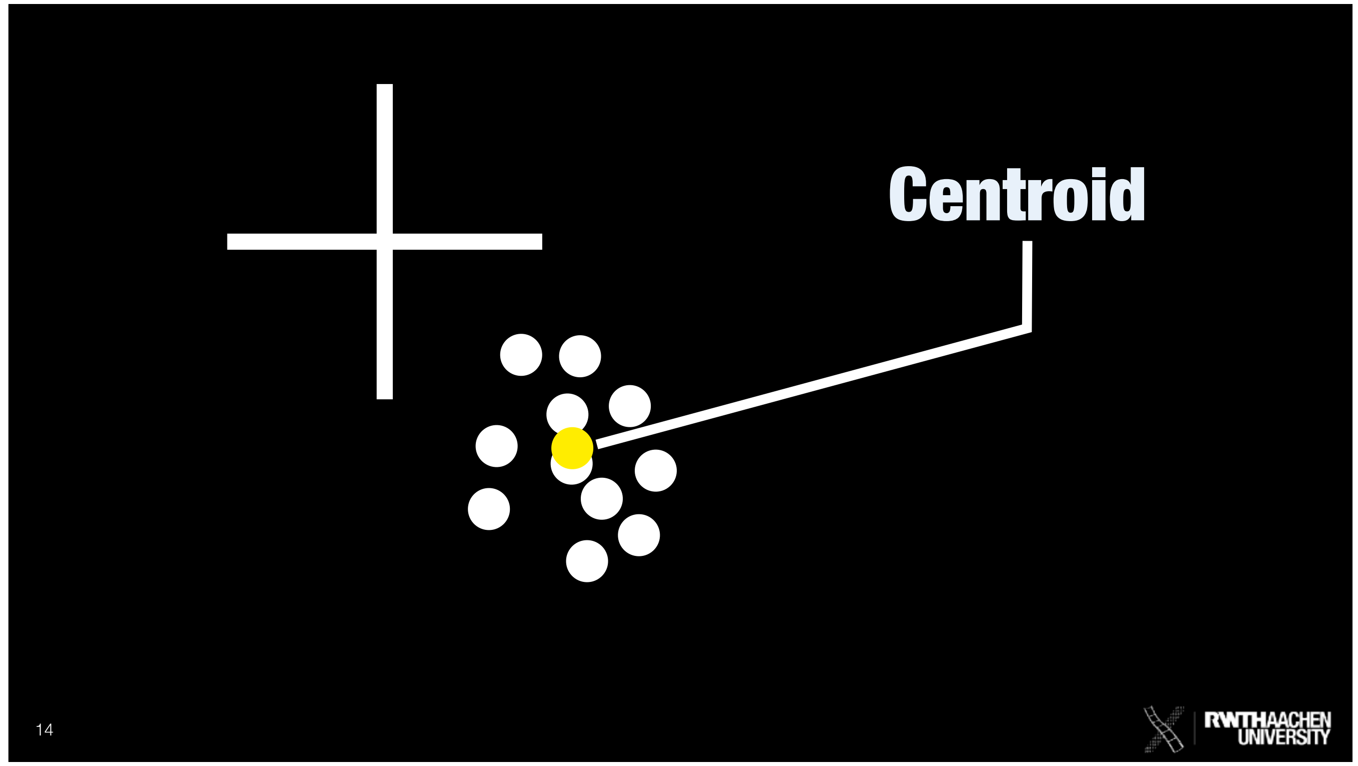


The center of the point cloud is called the Centroid.



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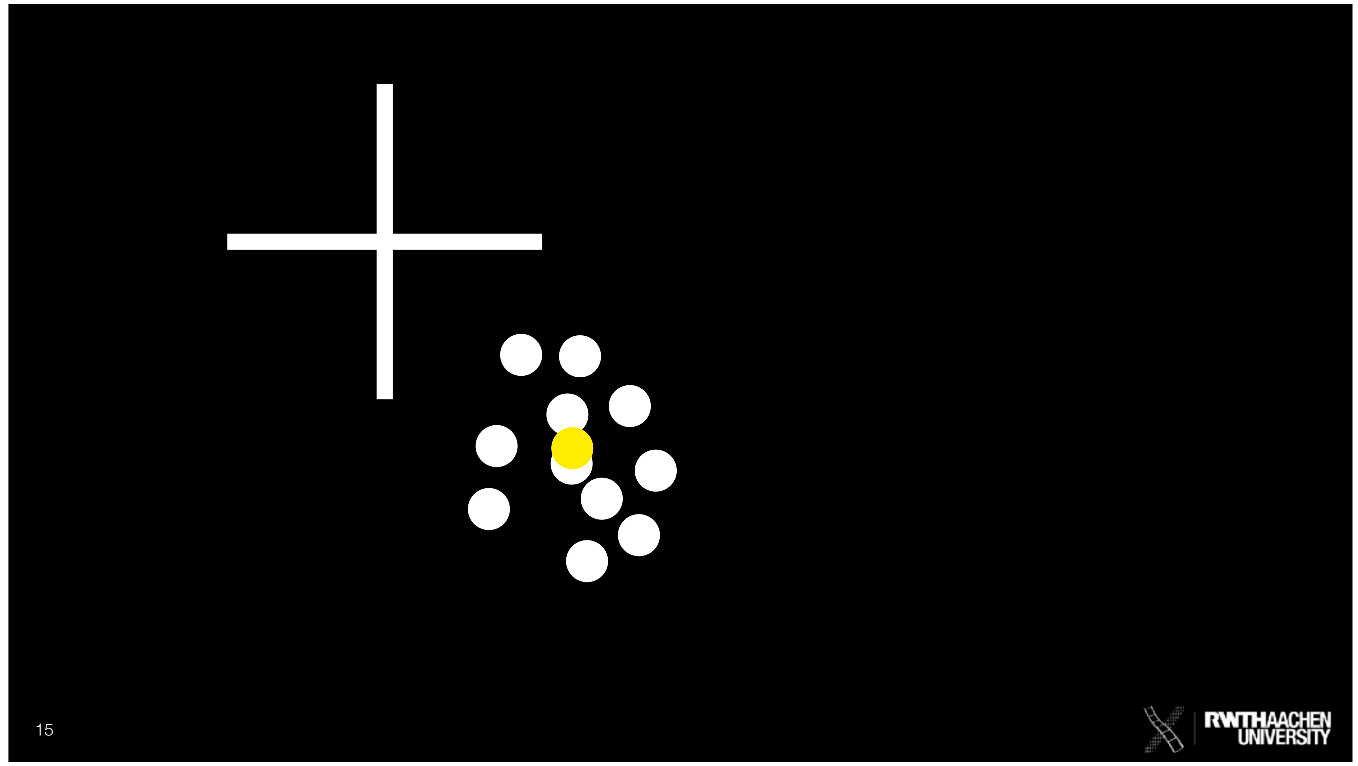
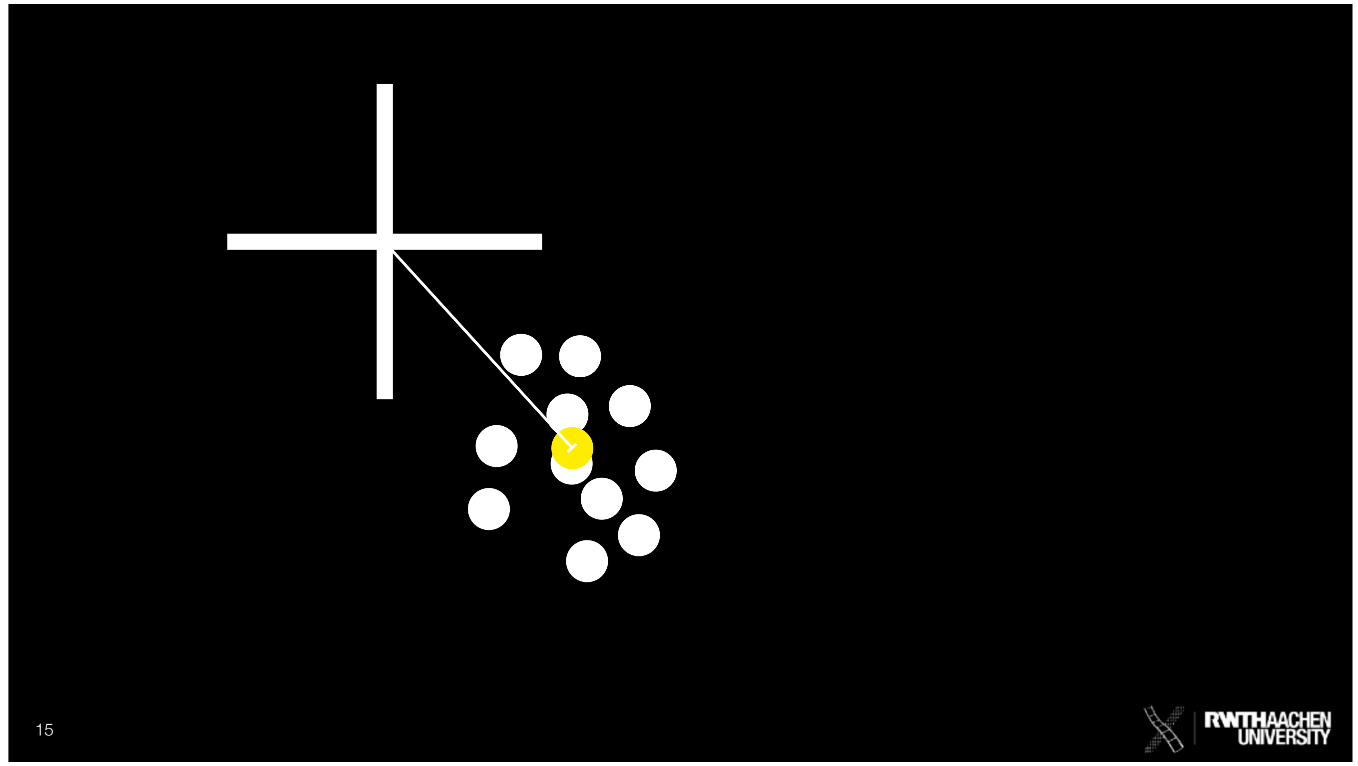


The distance from the center of the touch target to the Centroid is called Offset



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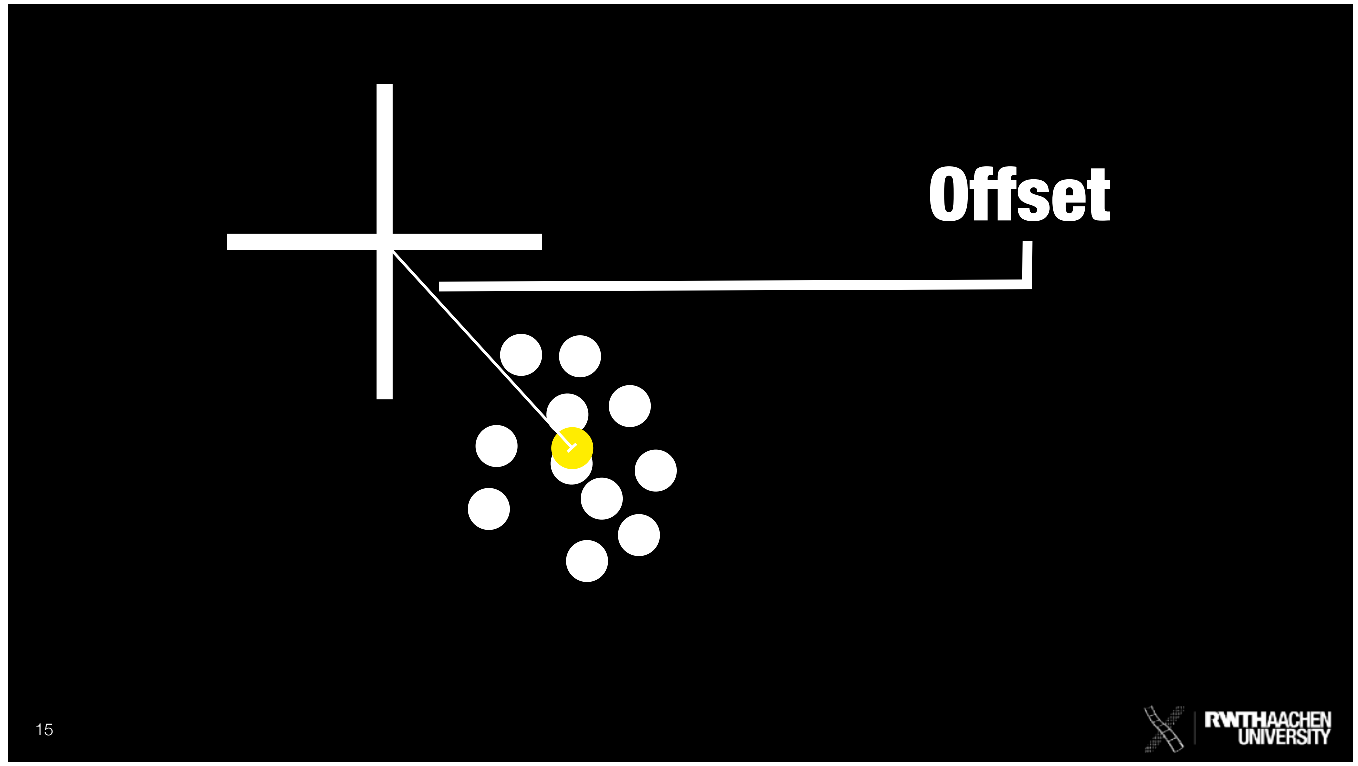

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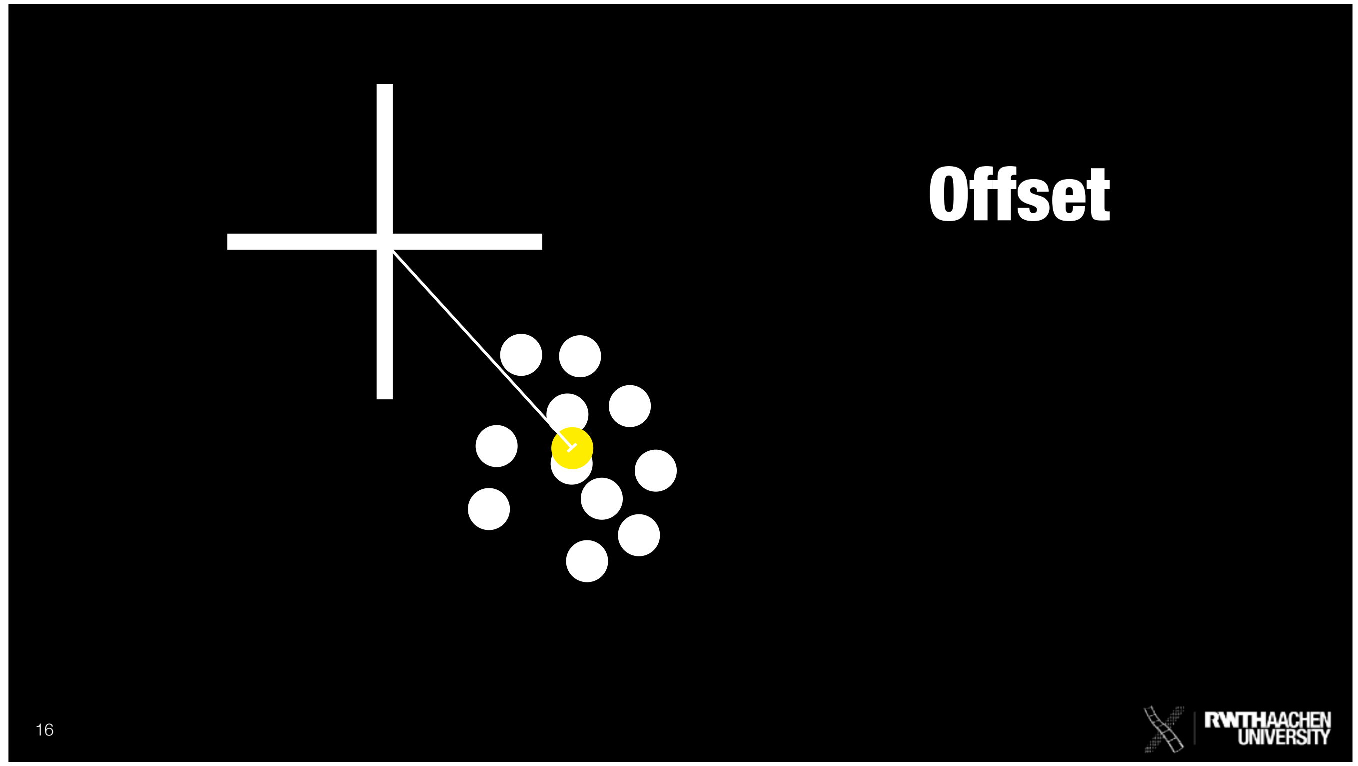
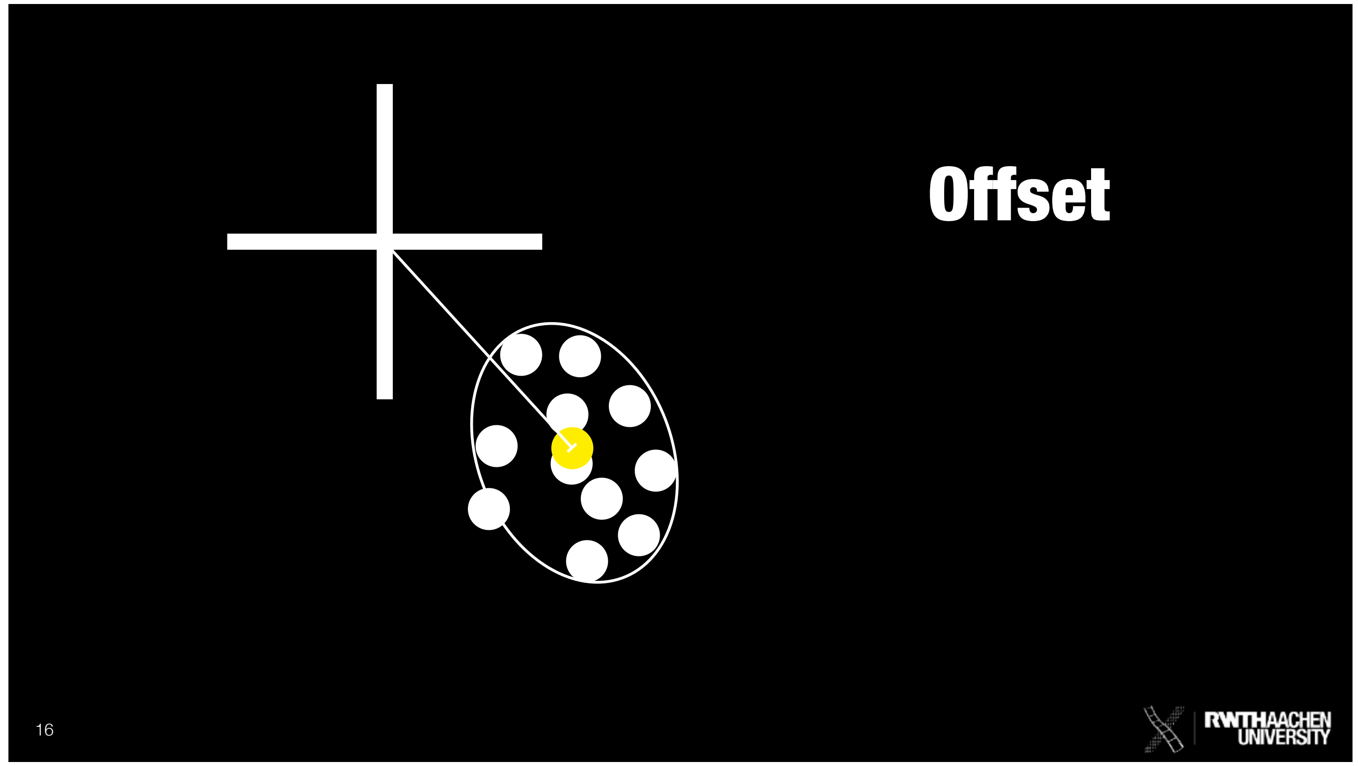


The Spread is the smallest Circle which still includes 95% of all touch points centered on the centroid.

Both Spread and Offset can be used to quantify touch accuracy.



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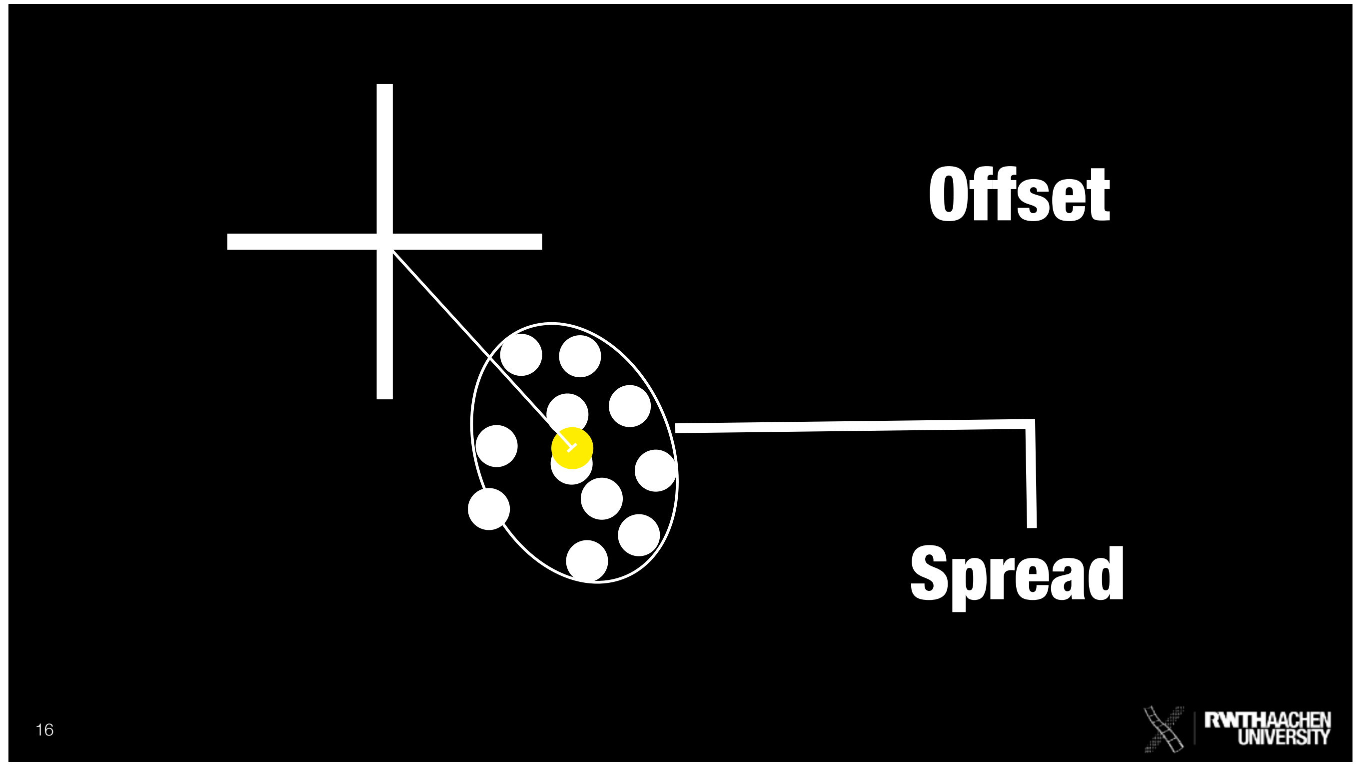

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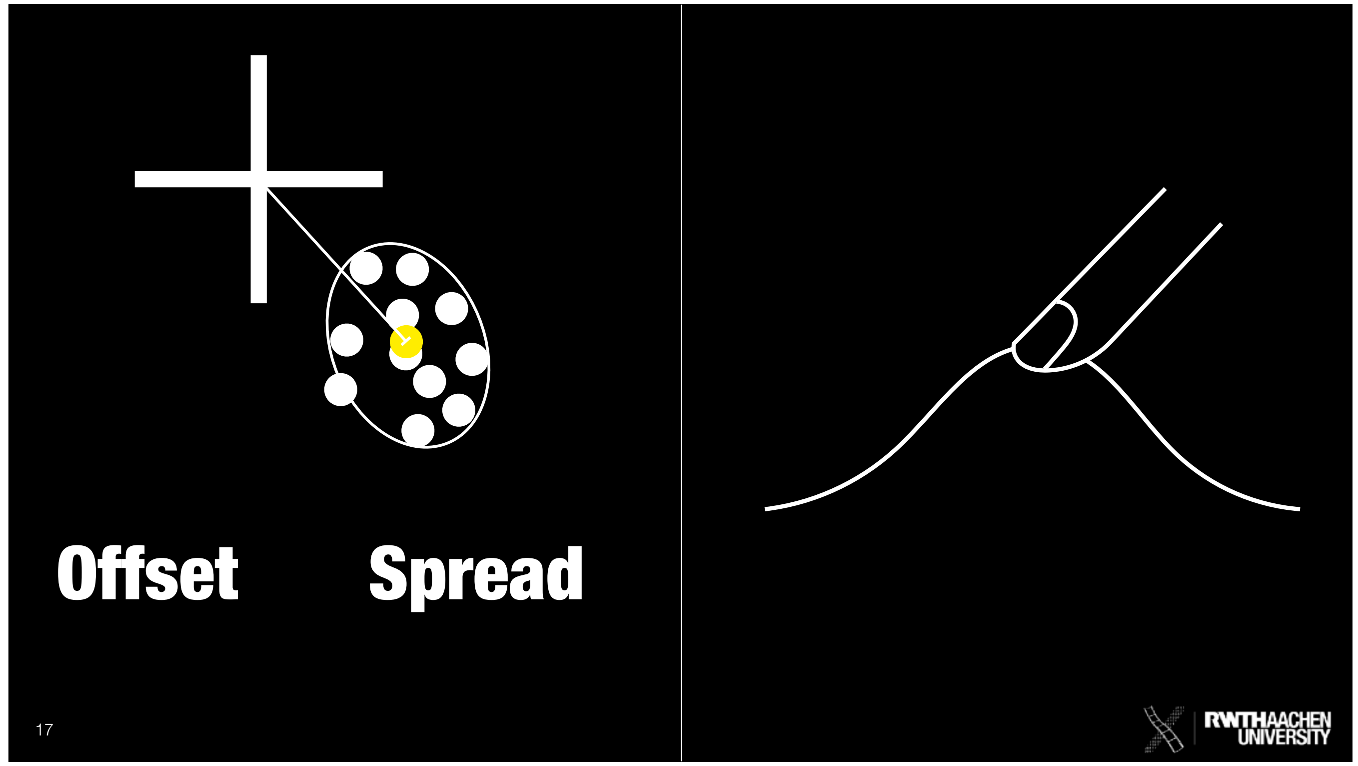
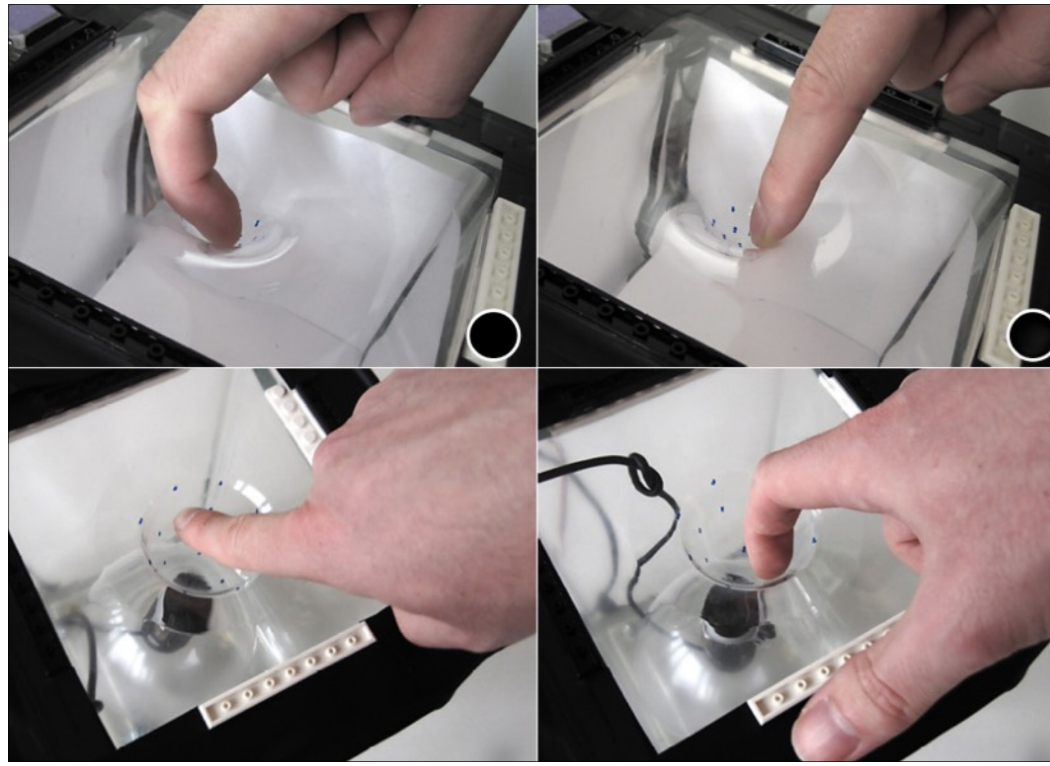


Now think about how Offset and Spread change on a convex curvature in comparison to a flat surface.

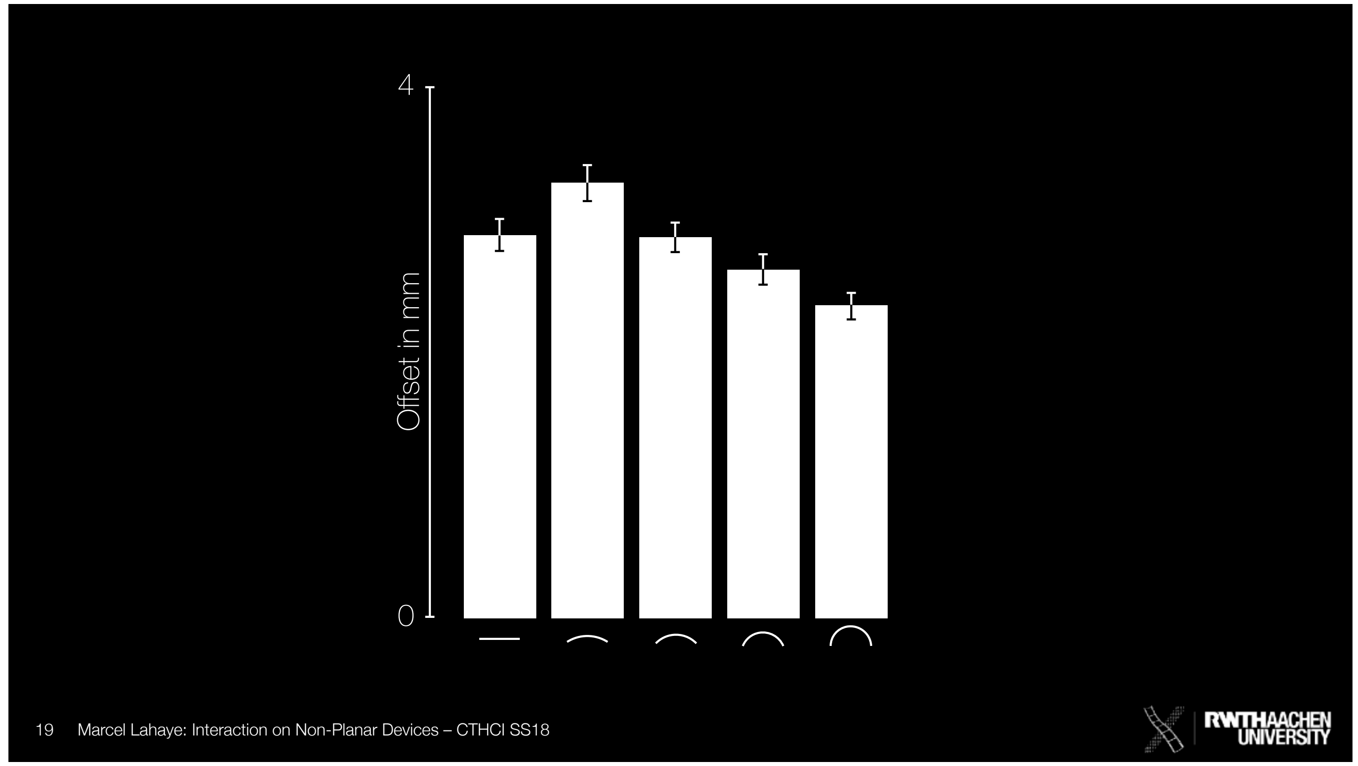


Touch Input on Curved Surfaces

Roudaut, Pohl, Baudisch

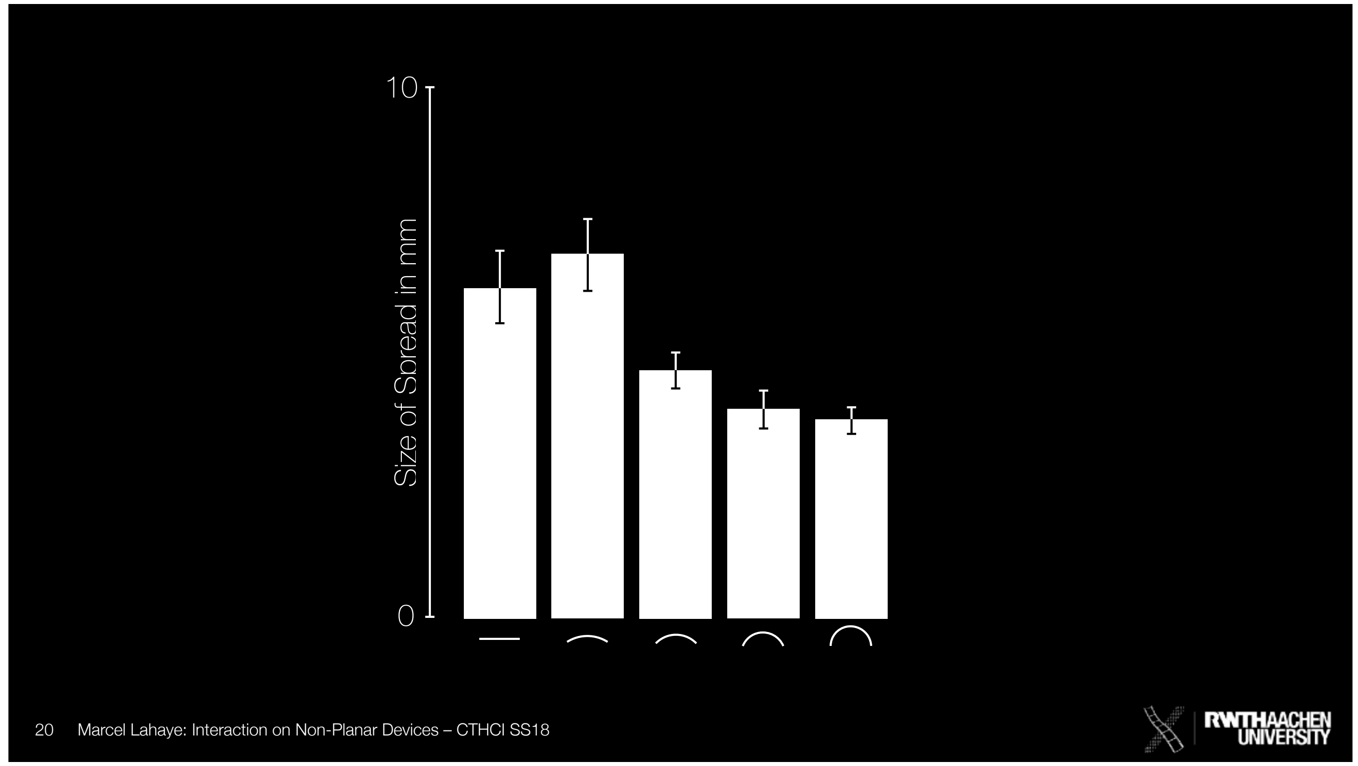
CHI'11

RWTH AACHEN UNIVERSITY



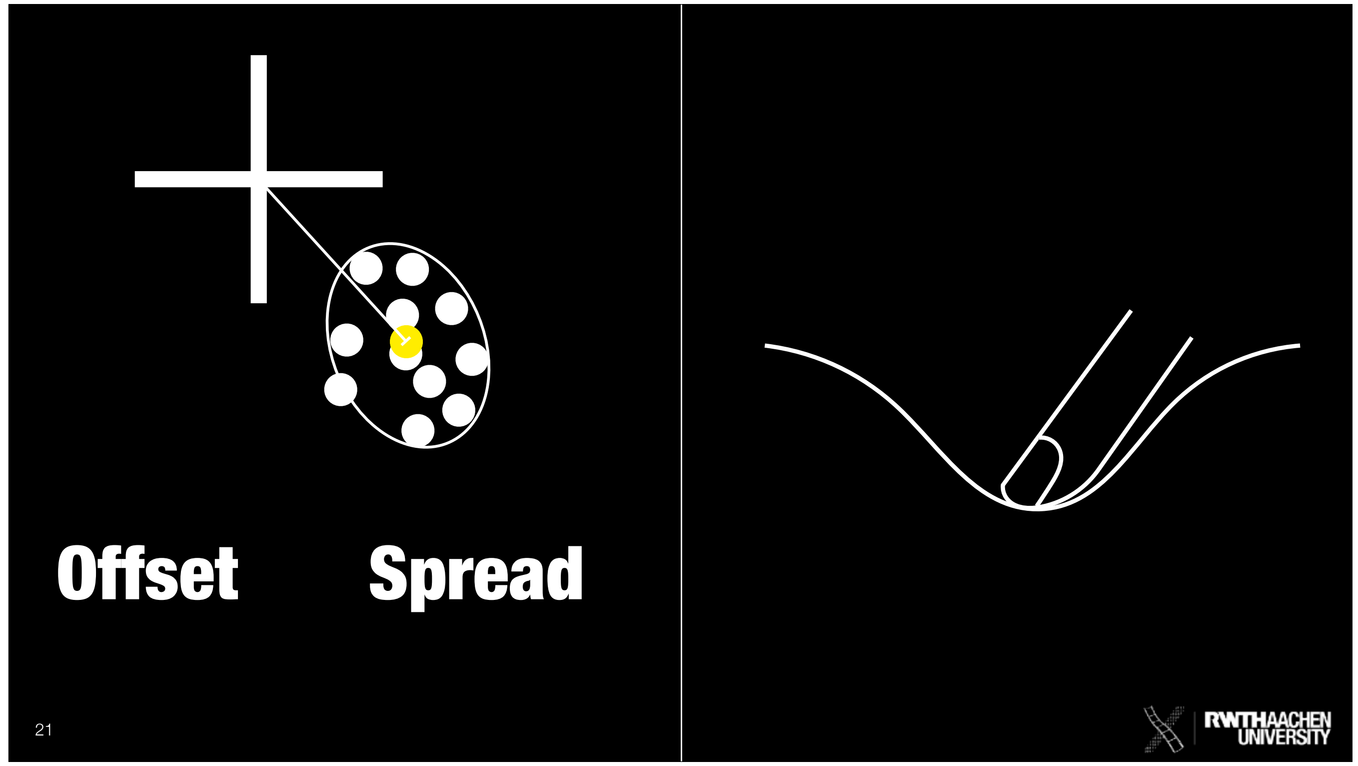
This is the average Offset and 95% Confidence Intervals for different degrees of convex curvatures from a user study presented by Roudaut et al.

Does this data match with your expectations? In general on a convex surface the contact area with your finger is smaller in comparison to a flat surface. You can visualise this in your head by imagining that the surface bends away from the finger.
This smaller contact area reduces the offset.

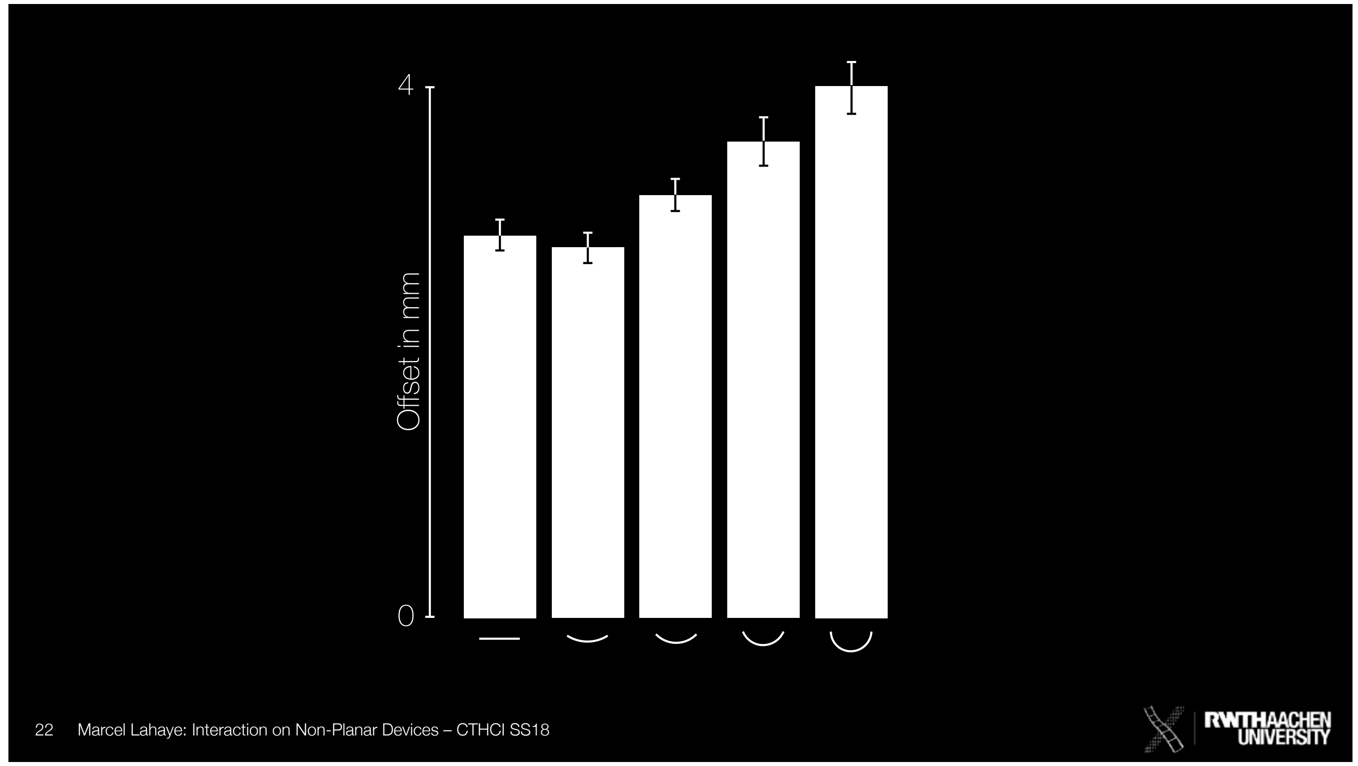


This is the average Spread and 95% Confidence Intervals for different degrees of convex curvatures from a user study presented by Roudaut et al.

Due to the smaller contact area the Spread also decreases

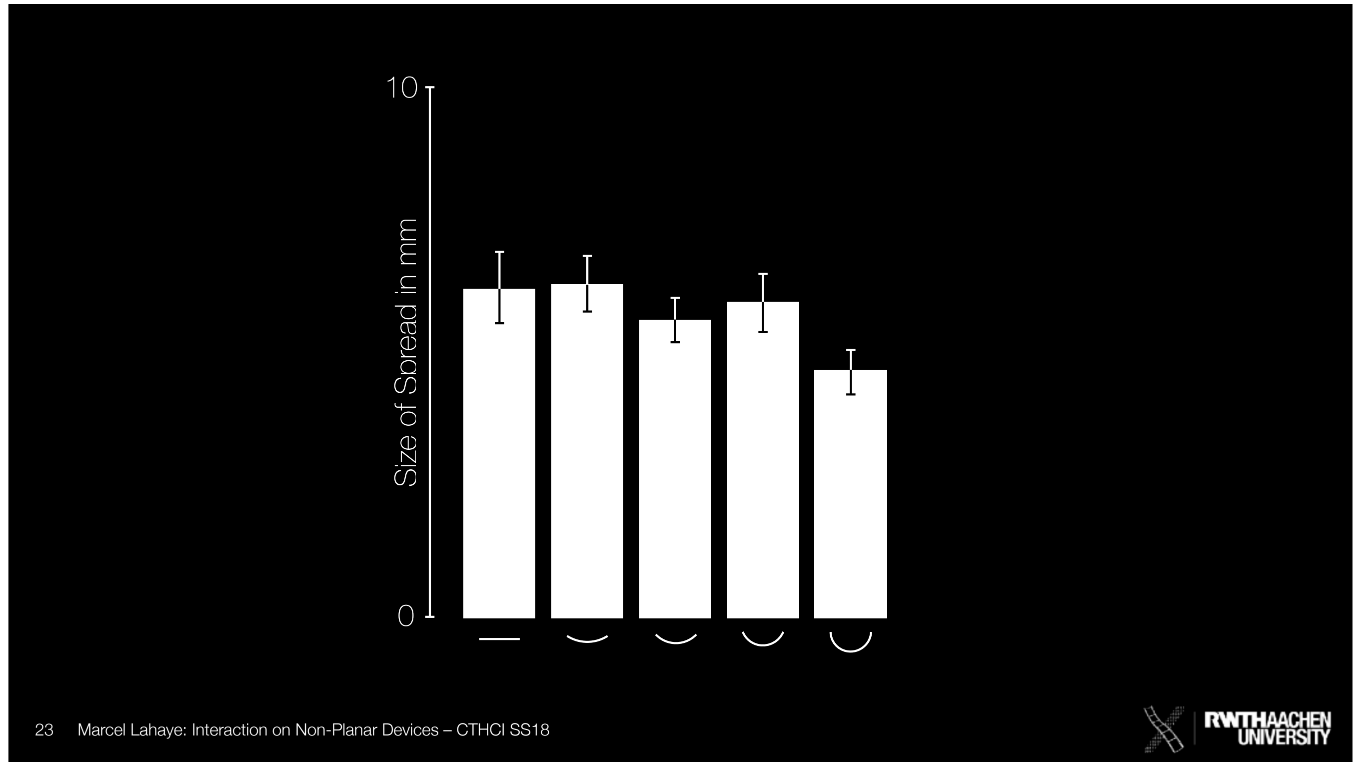


Now think about how Offset and Spread change on a concave curvature in comparison to a flat surface.



This is the average Offset and 95% Confidence Intervals for different degrees of concave curvatures from a user study presented by Roudaut et al.

A concave curvature wraps more around the user’s finger in comparison to a flat surface. The data shows that this increases the offset.



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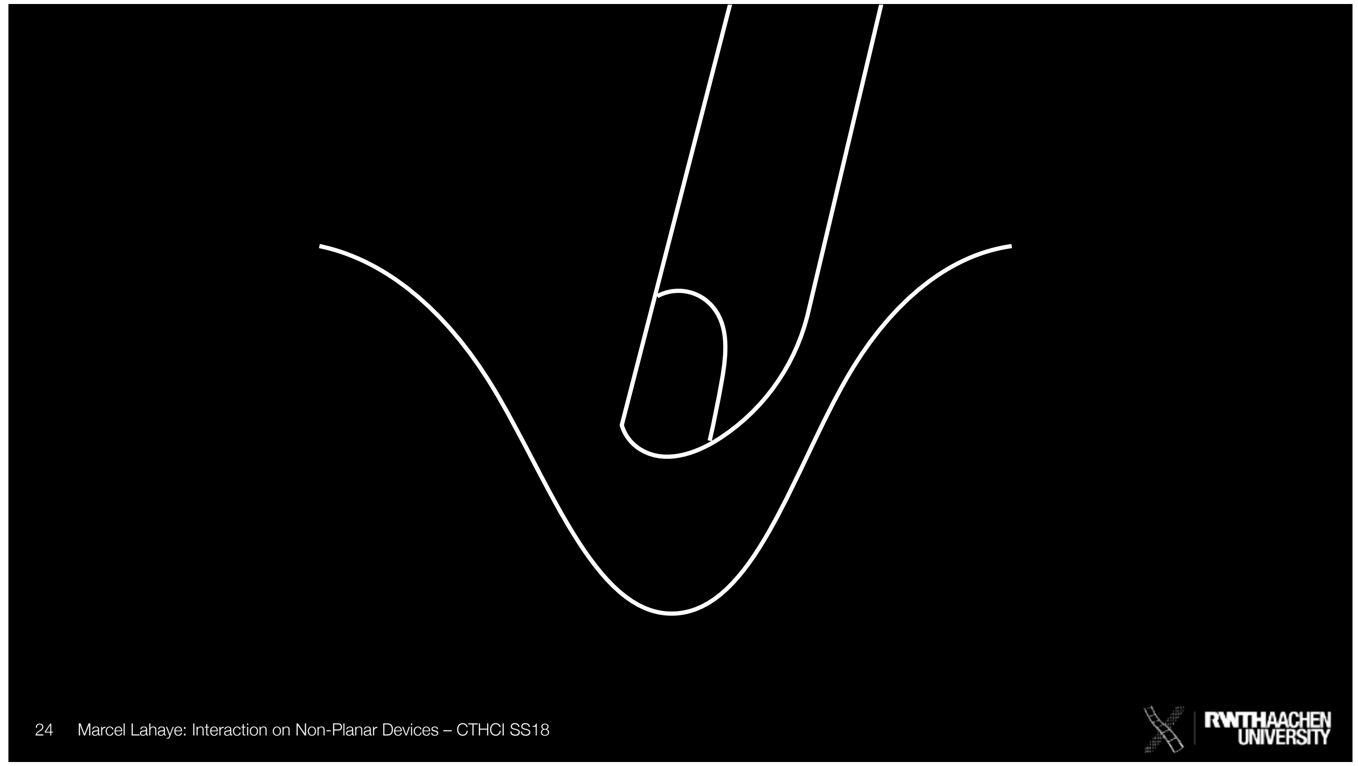
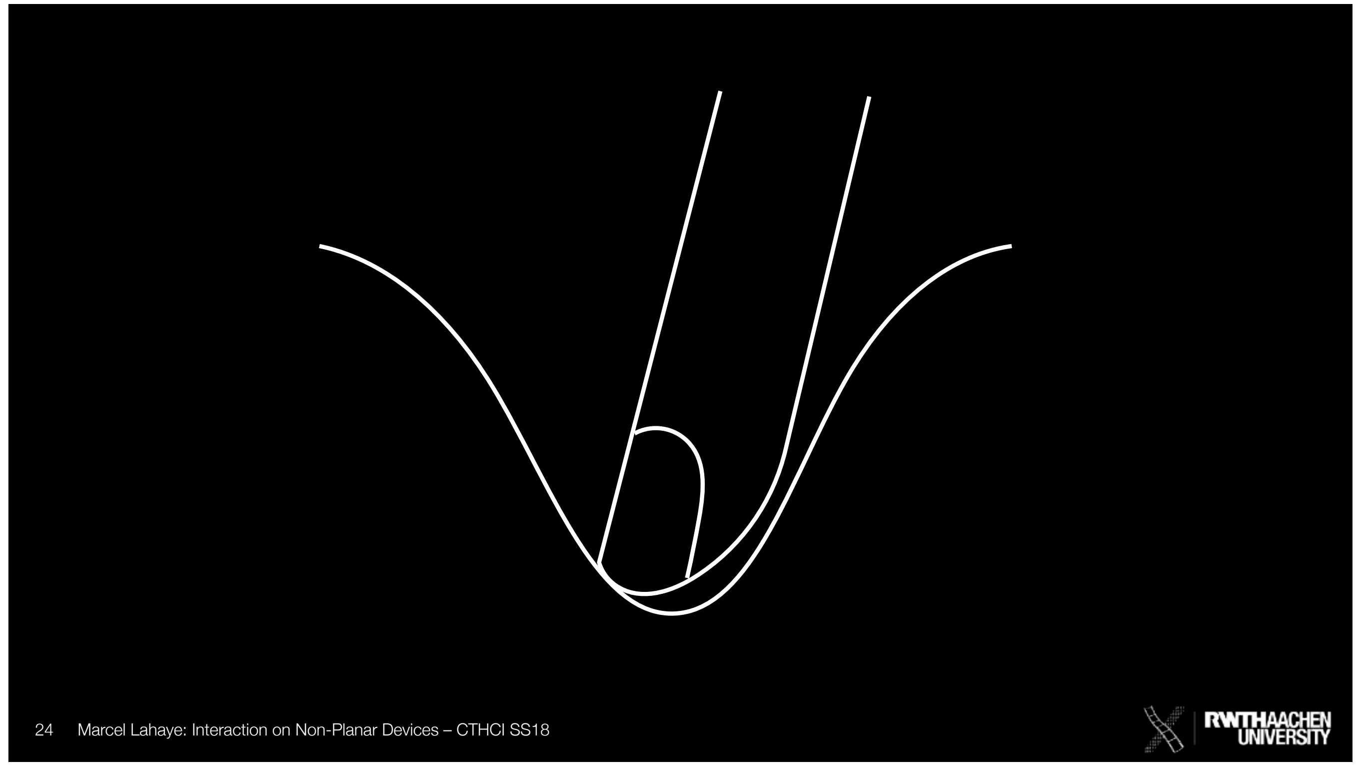
In contrast to possible expectations the spread decreases with increasing degree of curvature on a concave surface.



The authors of the paper assume that the decrease in spread exists because the funnel like shape of the concave surface can act like a guide for the user. Additionally, on a concave surface the downhill slopes are convex which might provide the beneficial influence from a convex surface on the touch accuracy.

You can read more details about this in the paper https://doi.org/10.1145/1978942.1979094



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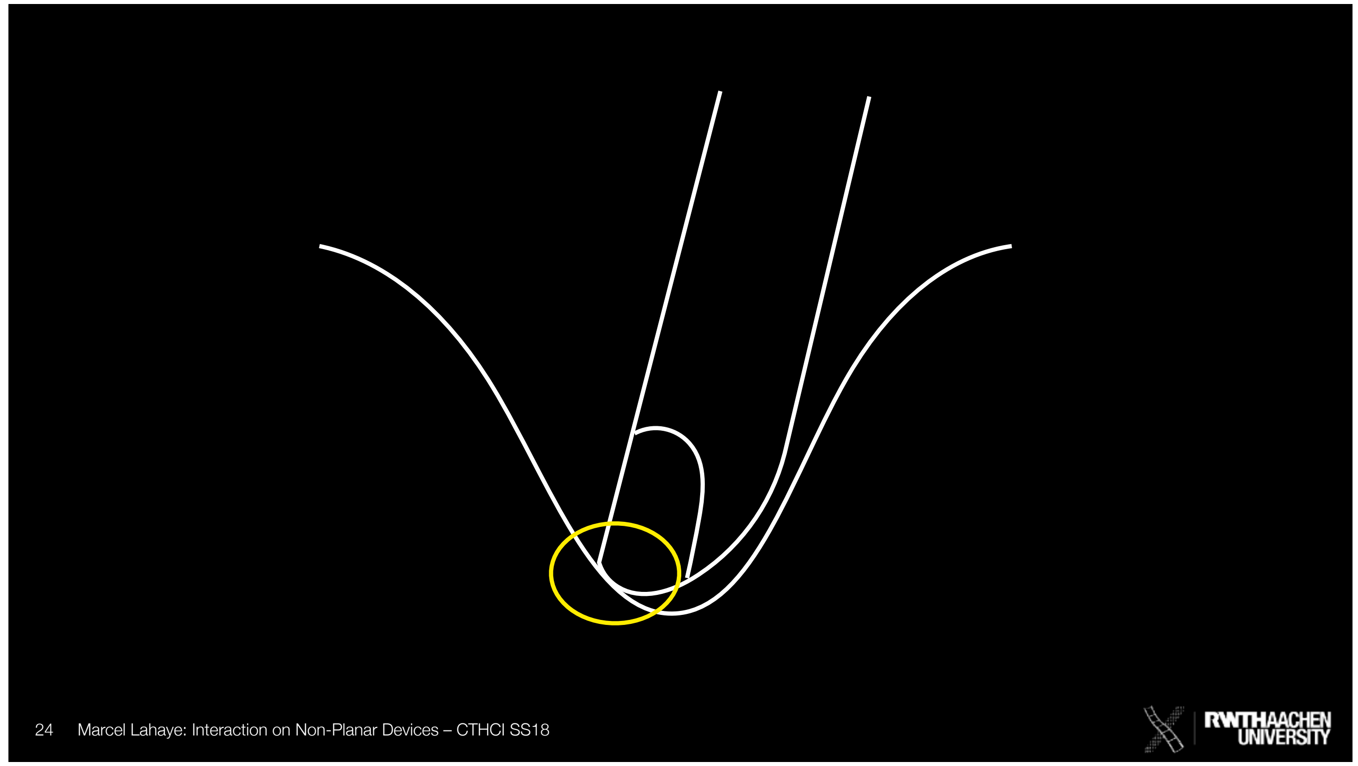

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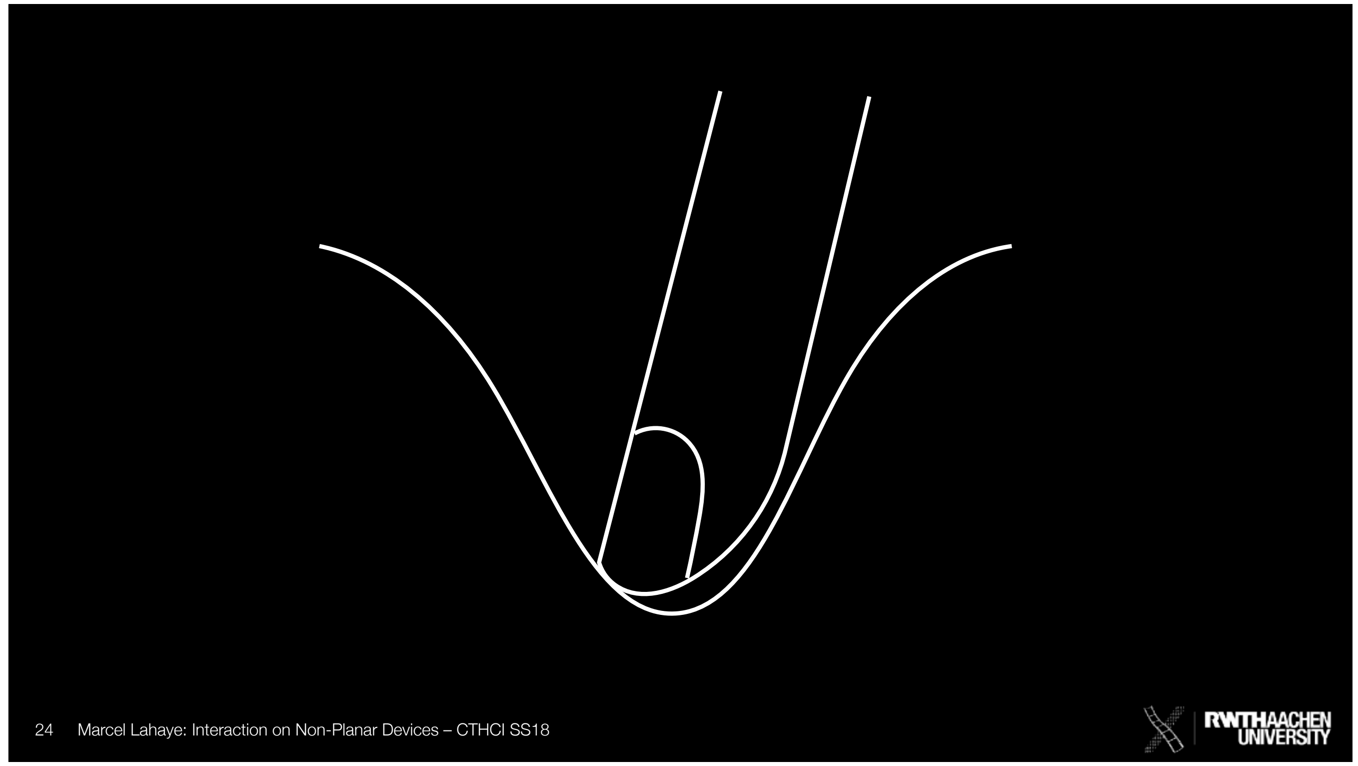

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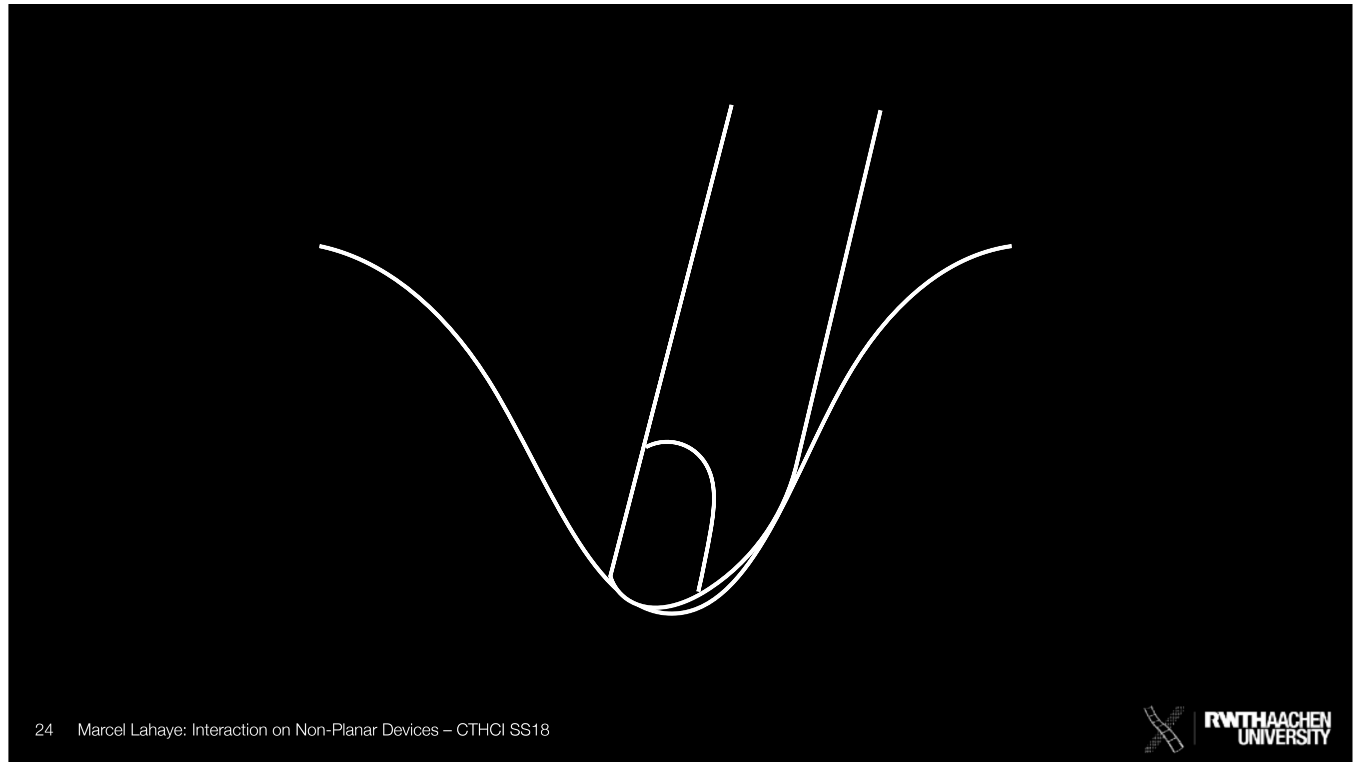

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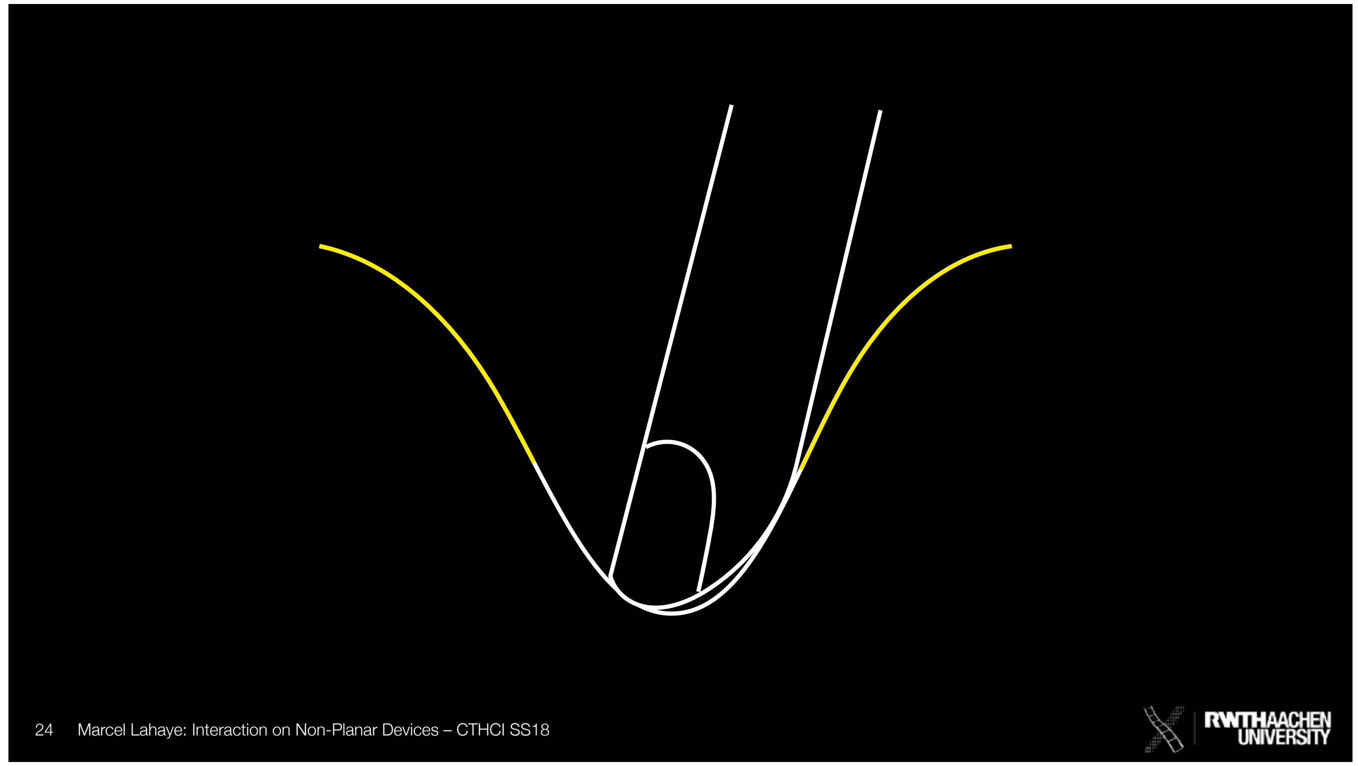

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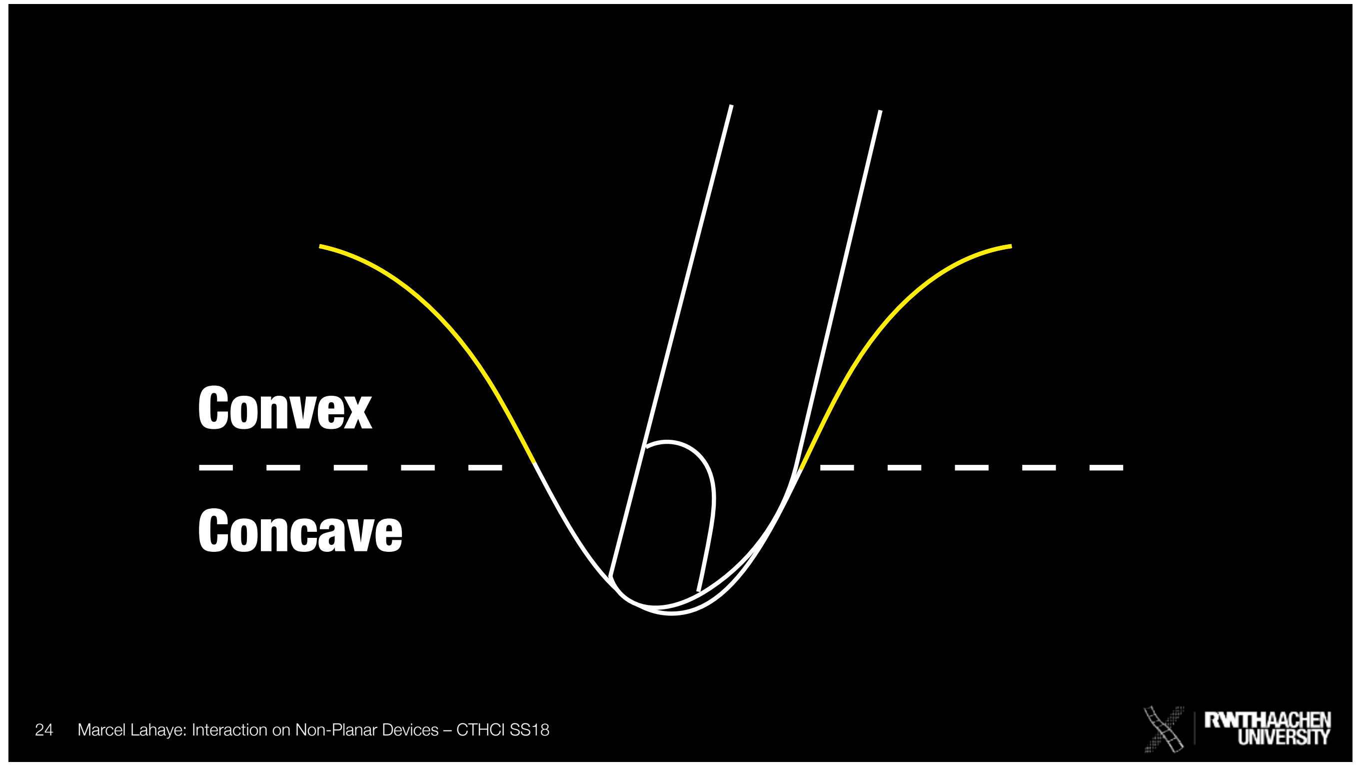

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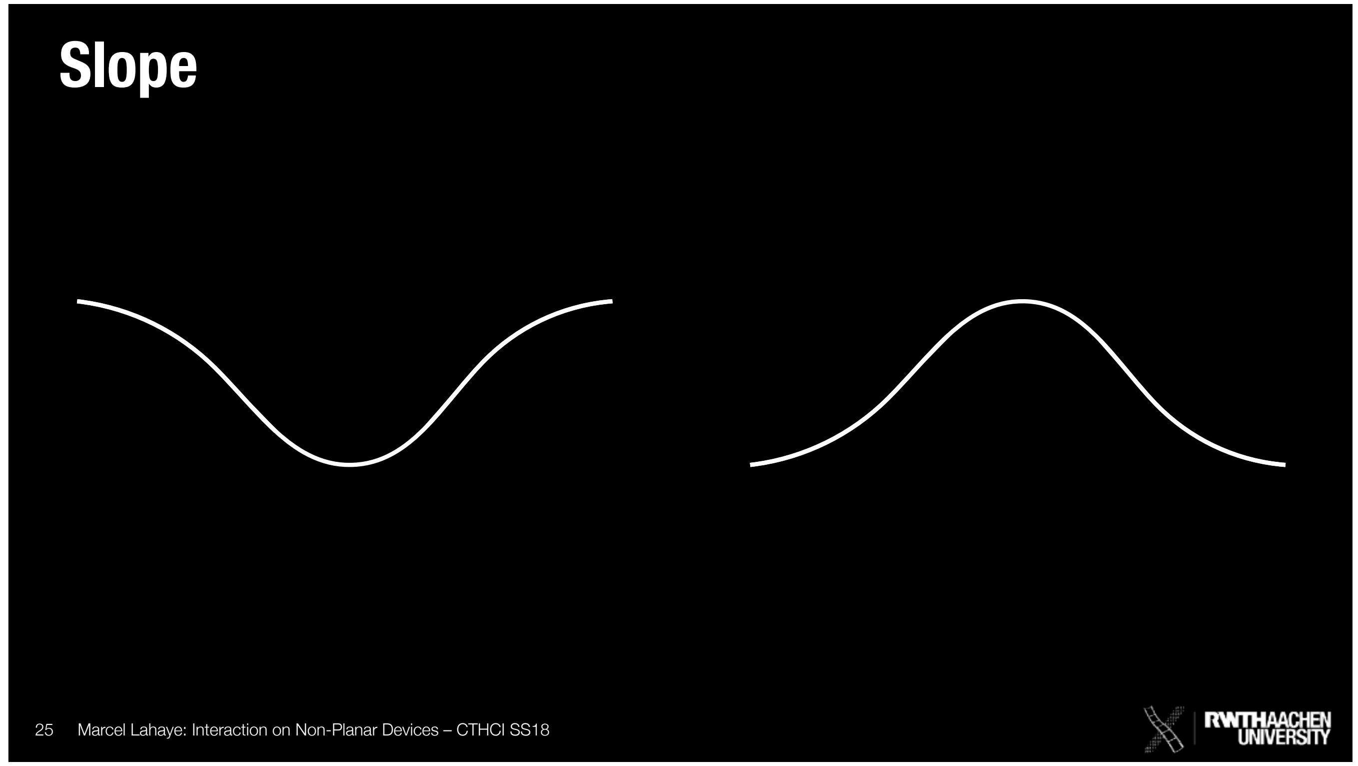
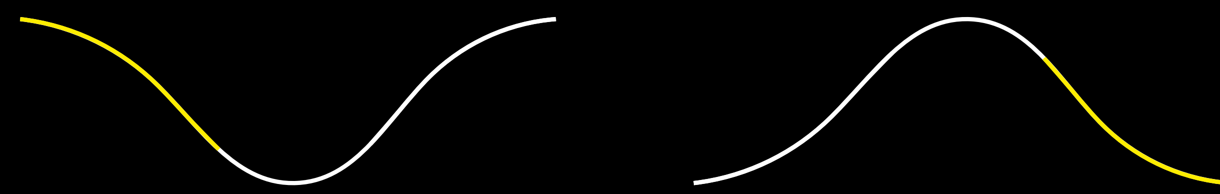


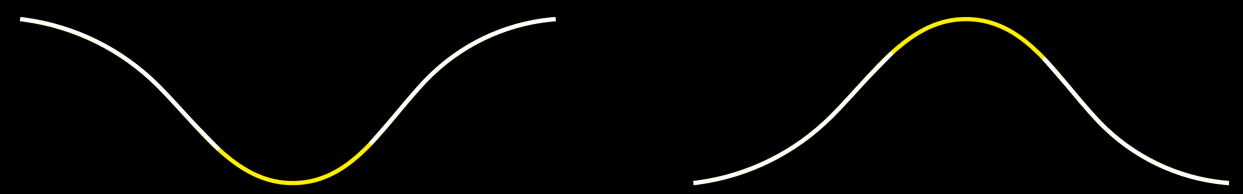
Apparently, the slope of a curvature is also influencing spread and error. Therefore, lets have a look which slopes exist on a curved surface.

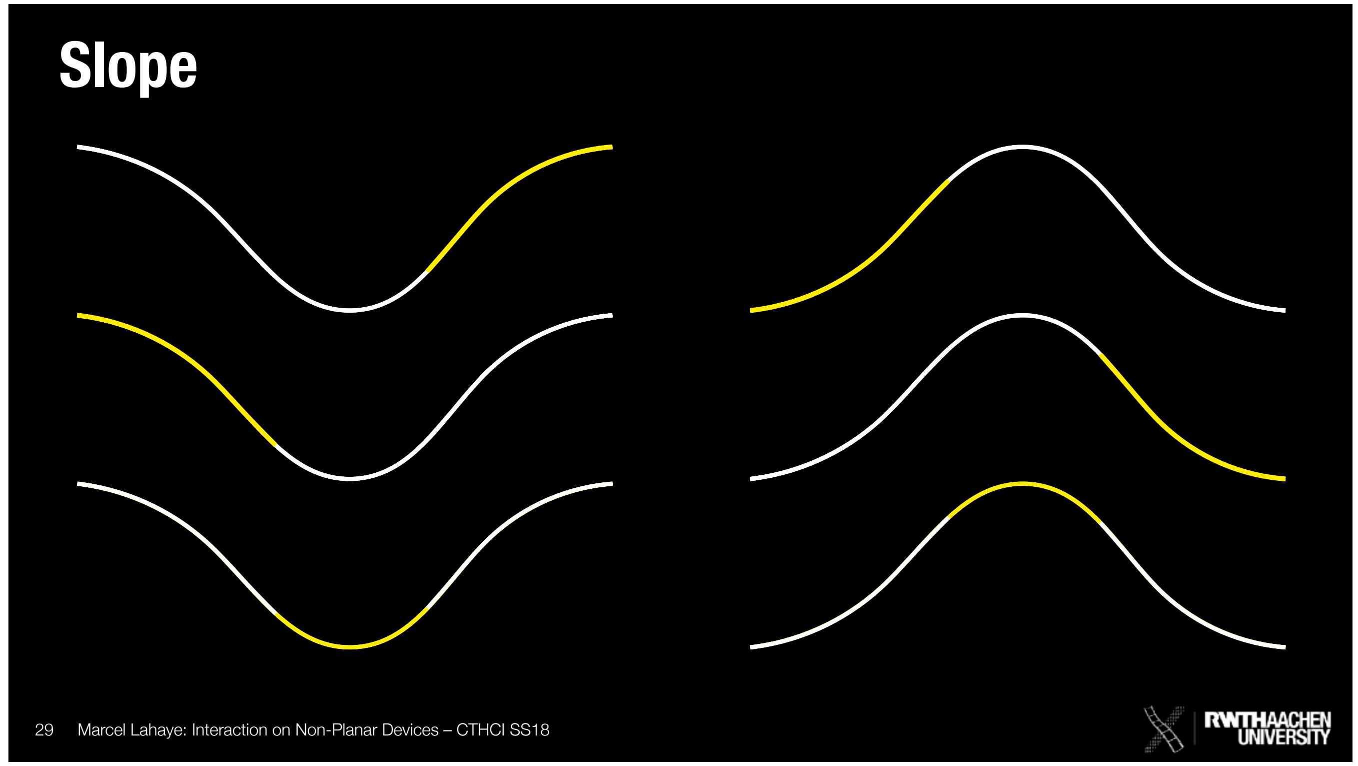
Downhill Slope

Uphill Slope

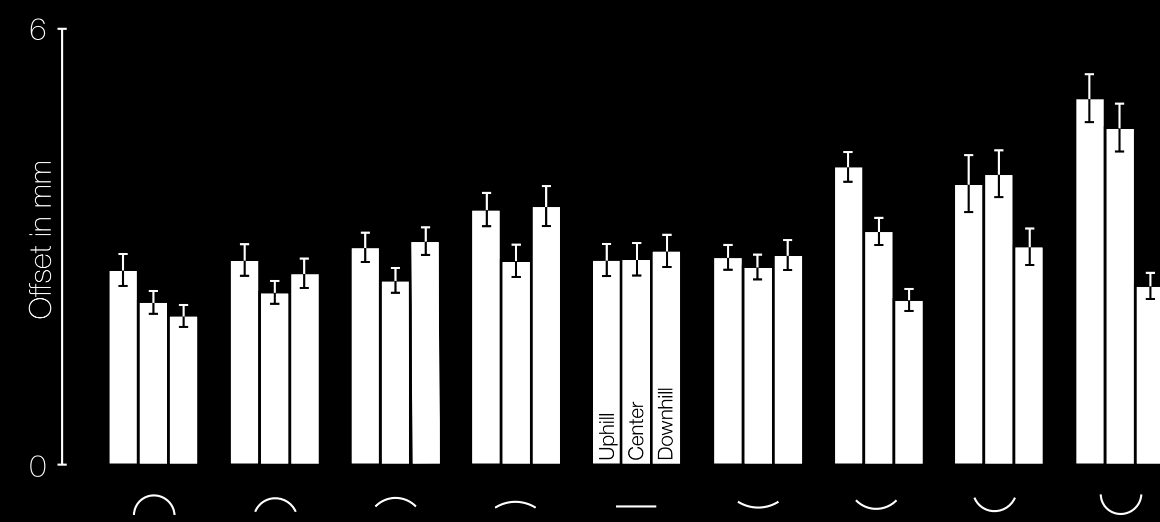


Center Slope





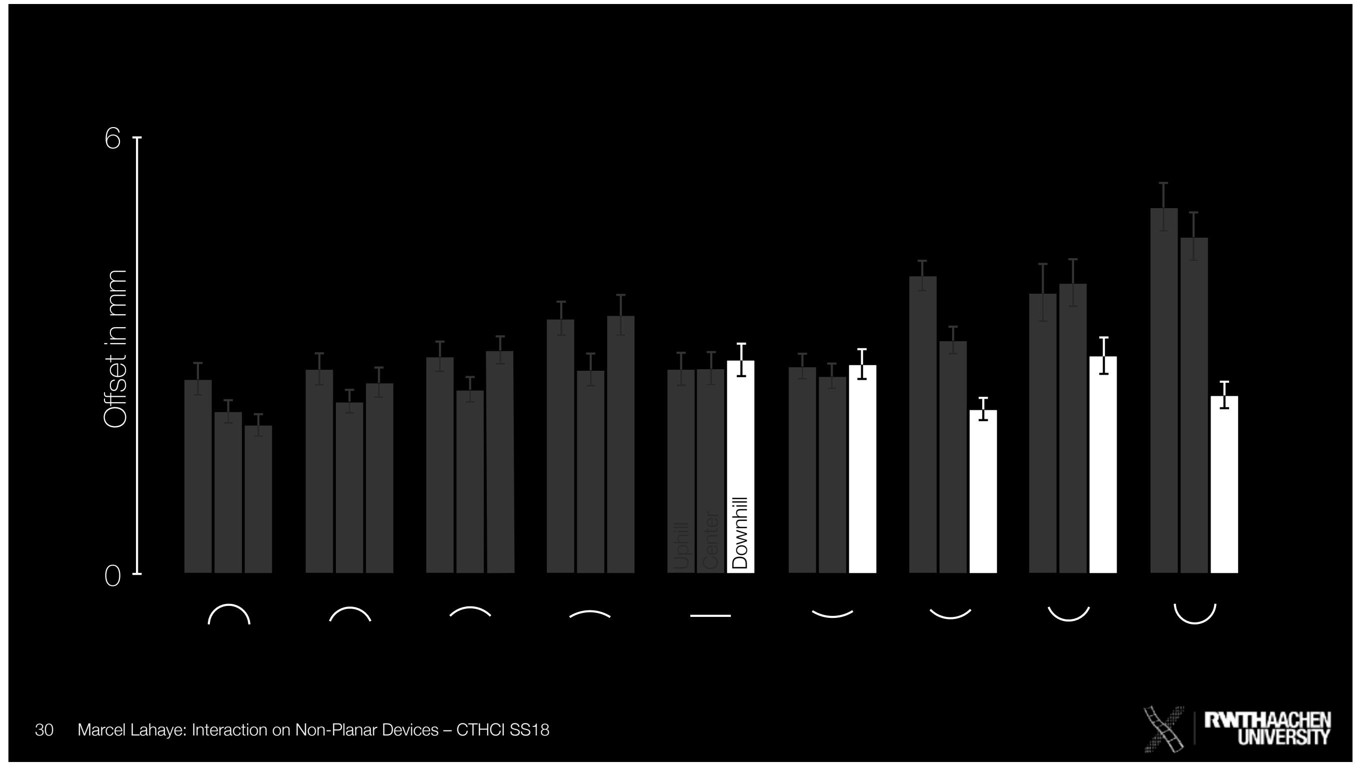
Take a moment to think about how these slopes might influence Offset and Spread.



There is no significant effect of the slope on the Spread.

The results for the effect of the slope on the Offset are shown in the graph. The graph shows the average Spread and 95% Confidence Intervals for the slopes of different degrees of curvatures from a user study presented by Roudaut et al.

Interesting here is that for the downhill slope on a concave surface the Offset decreases.



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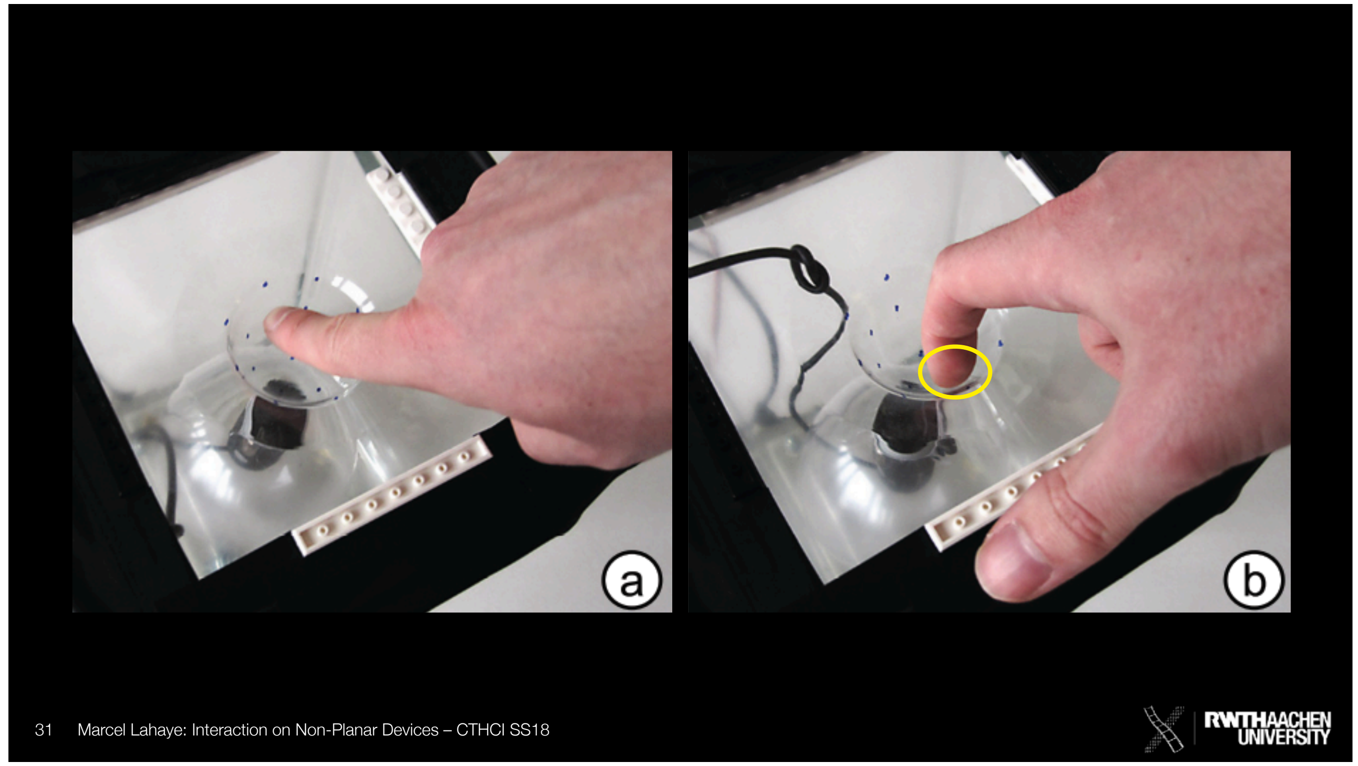
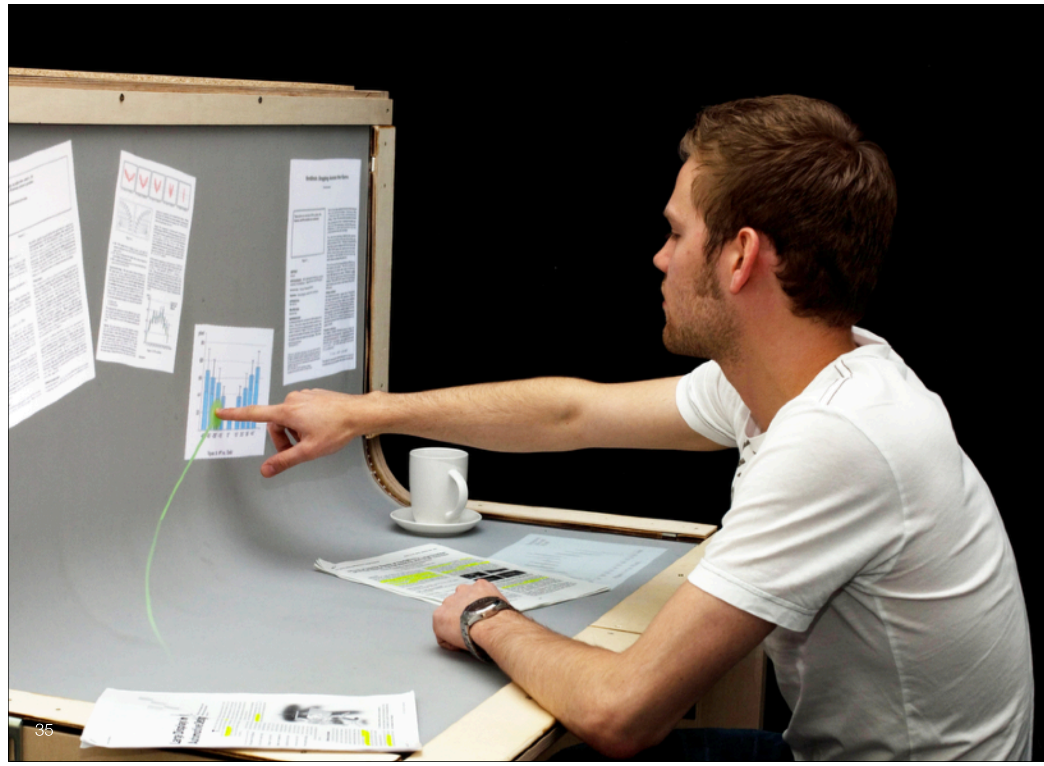


The decrease in the Offset for the downhill slope on a concave surface might happen due to a unique gestures users apply for downhill slope targets. The user forms a hook with the finger. Because of this gesture the part of the finger which is in contact with the surface is visible. This gives the user visual feedback when aiming for the touch target.

Improved **working metaphor** for note taking and annotations

When working with computers or having meetings we mostly still annotate on the side.

Tablets with a keyboard cover enable a switch from typing to note taking but still require this active mode switch.



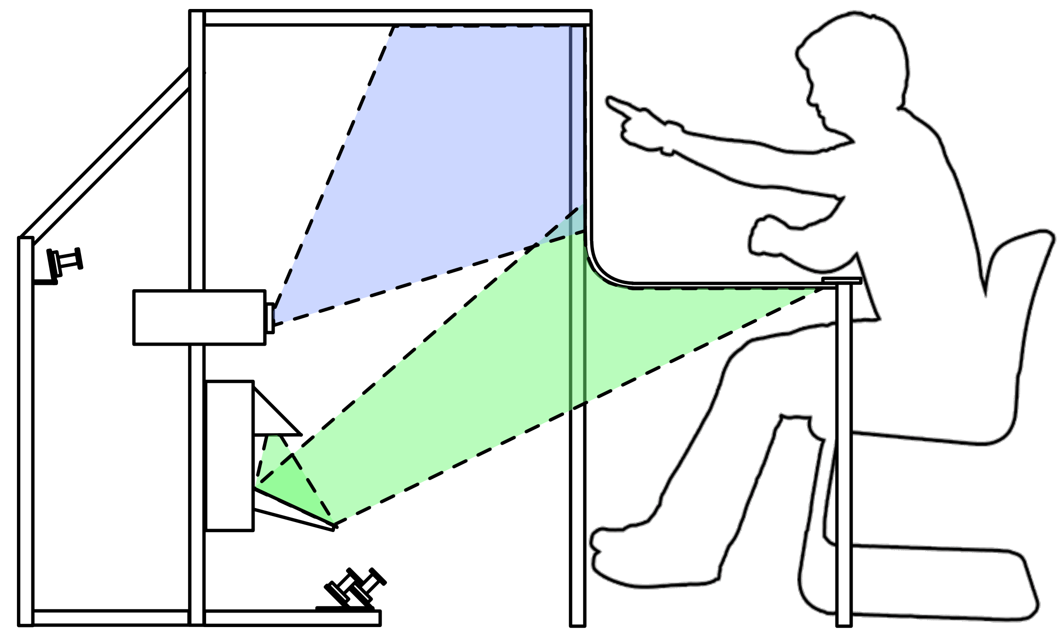
BendDesk: Dragging Across the Curve

Weiss, Voelker, Sutter, Borchers

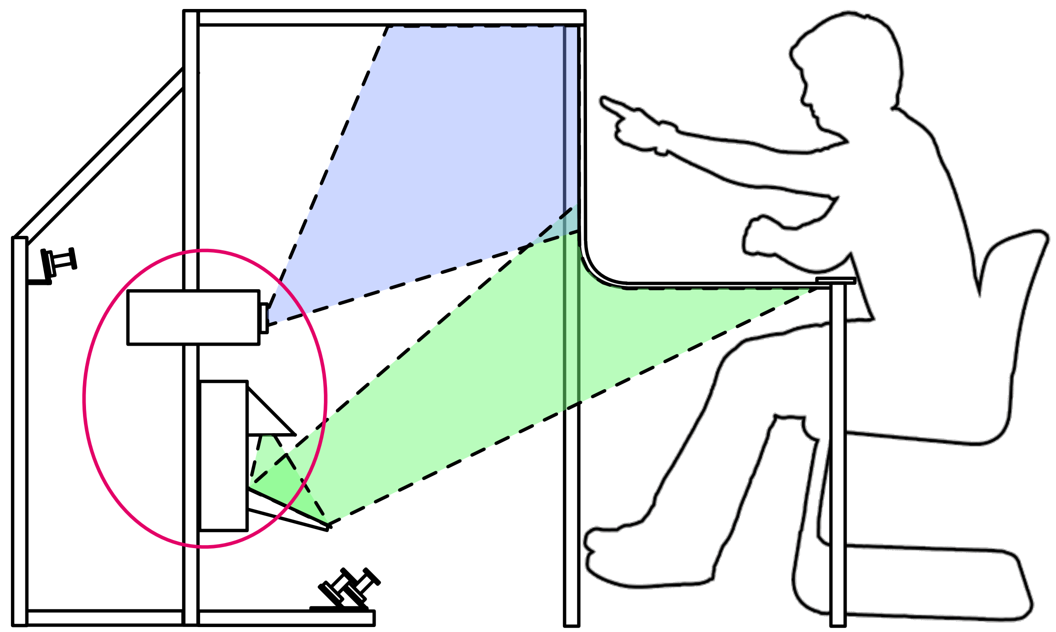
ITS'10

35

BendDesk introduces a large touch display which seamlessly connects a vertical and a horizontal surface.



The BendDesk construct uses two projectors to project the content on the curved interaction surface. Infrared cameras capture the user’s touch points.



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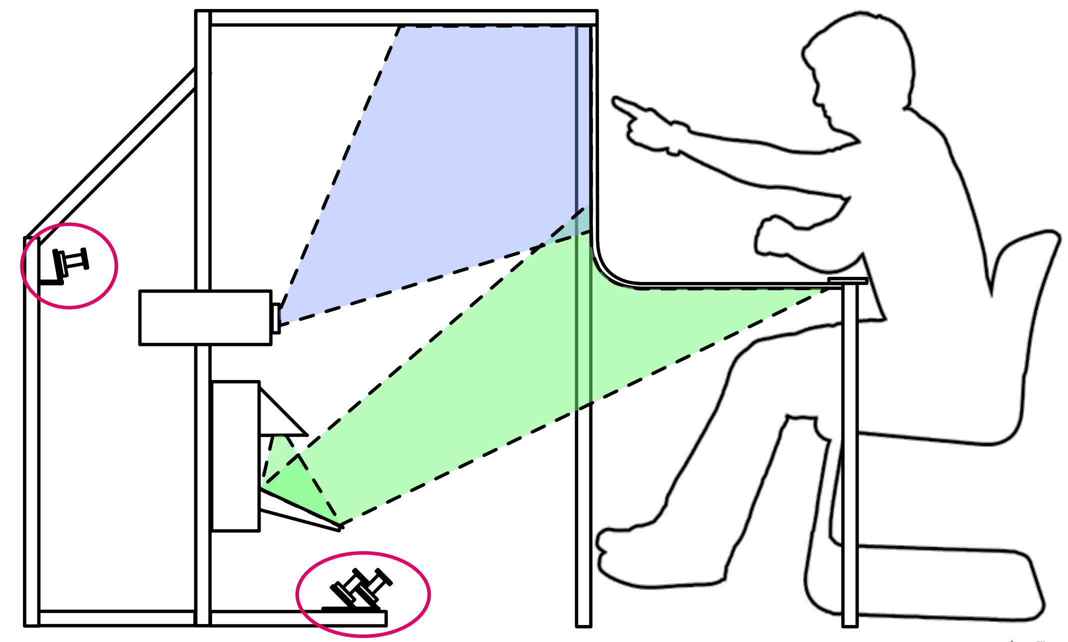

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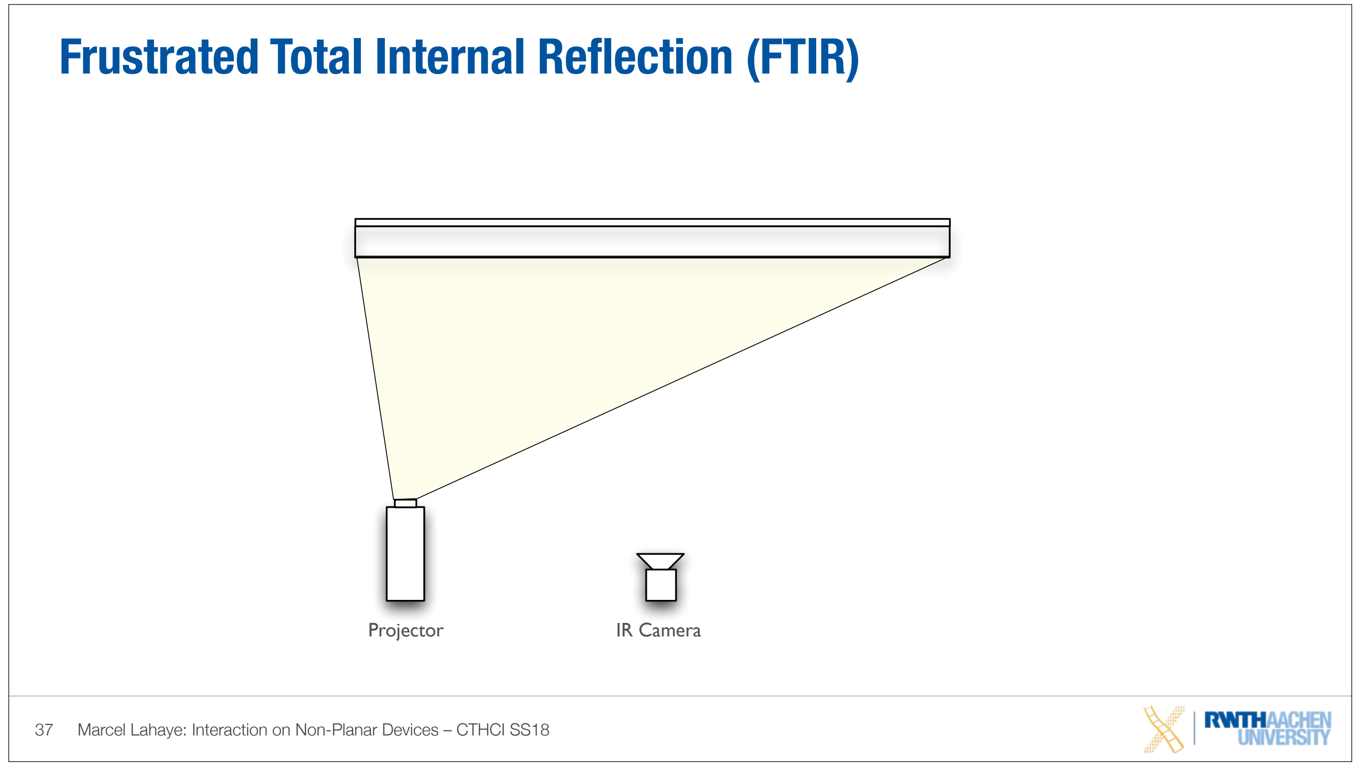
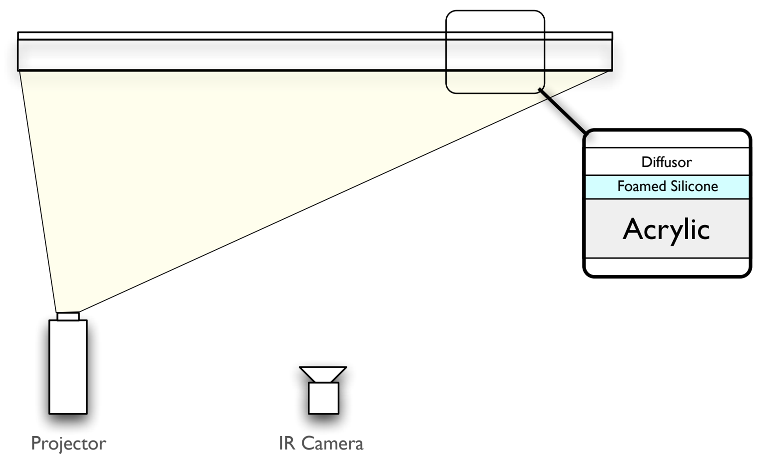


BendDesk uses the optical touch sensing technology FTIR. Infrared light is emitted into the acrylic layer. A finger touching the surface bends the acrylic surface and therefore changes the refractive index. Due to the change of the refractive index the infrared light shines away from the finger which is capture by an infrared camera.

Pro:
+ Binary spot detection
+ Cheap
+ Number of detected spots only depends on CV algorithm
Contra:
- Sensitive to sunlight
- No hover effects

Frustrated Total Internal Reflection (FTIR)



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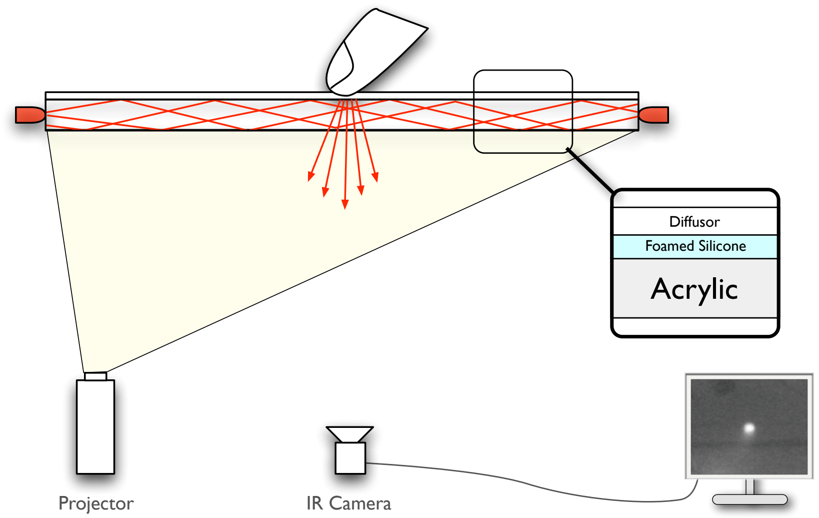

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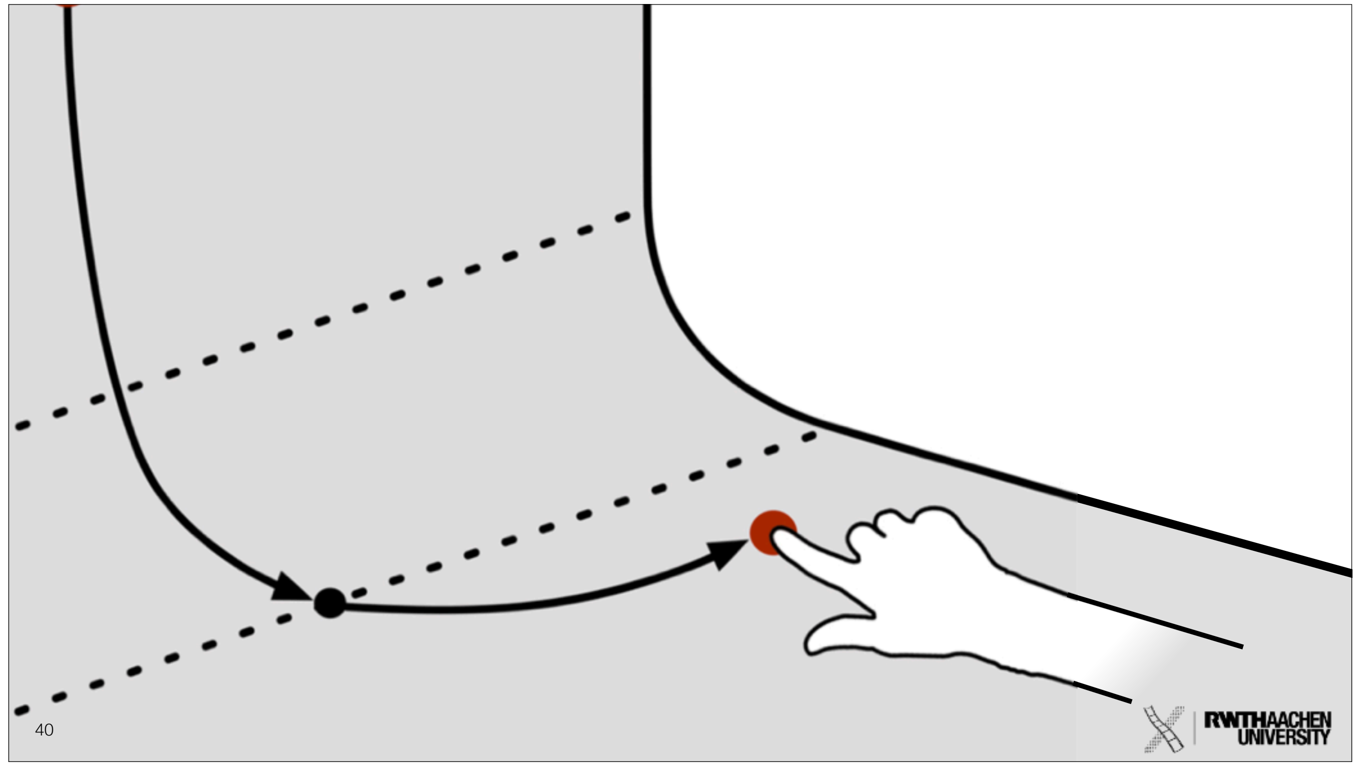
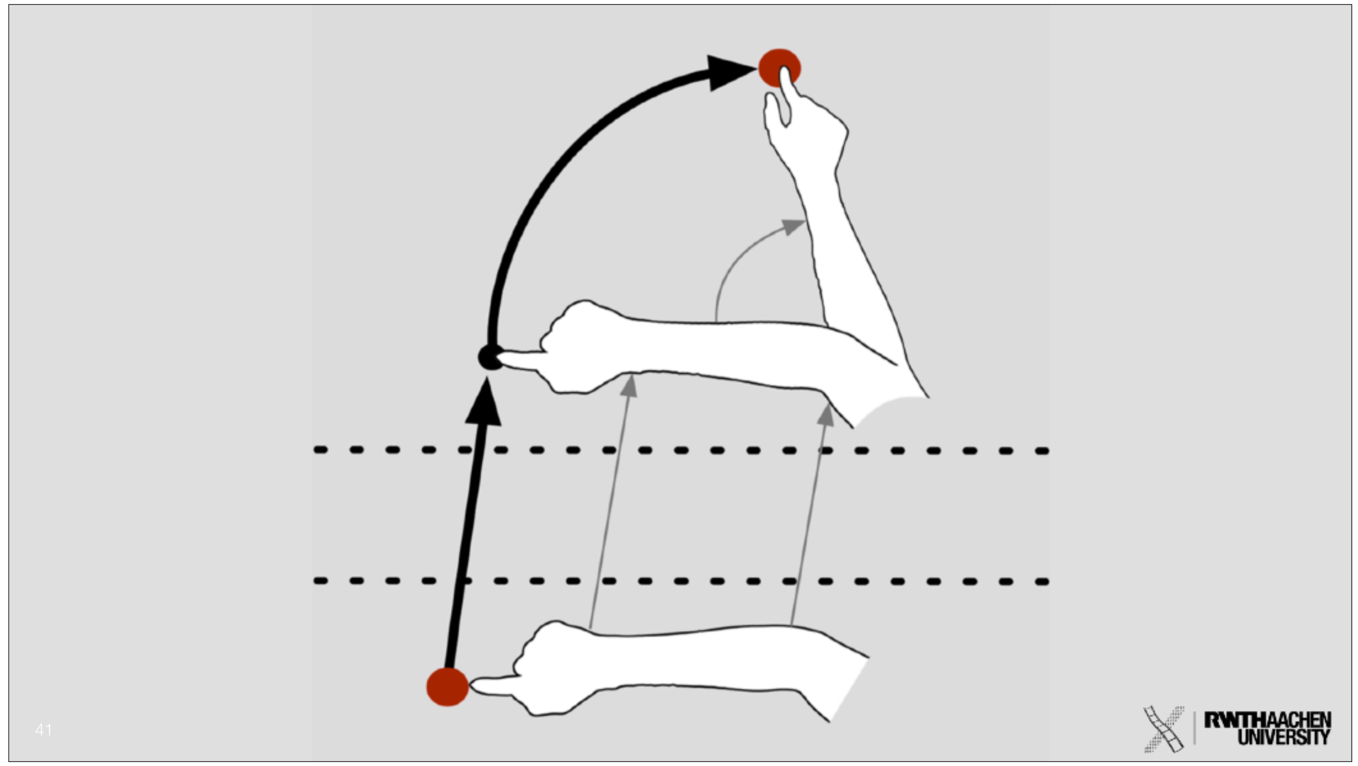
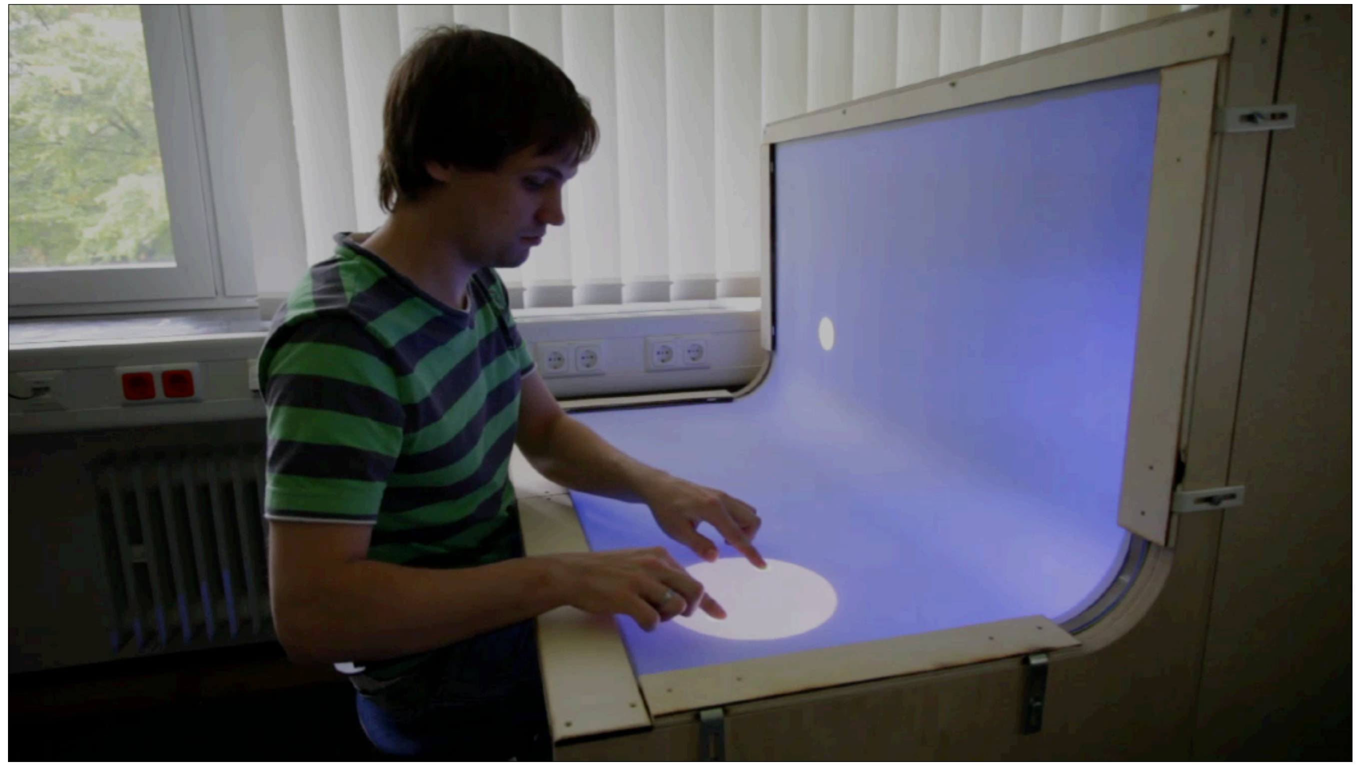
Dragging along the curve of the bend surface feels different for the user in comparison to a flat surface. The finger position changes on the curve and also friction feels differently because the finger contact area might increase on the concave surface. Additionally, the user's fingertip and fingernail might scrape along the surface. Therefore, you can observe that users try to minimise the contact with the curvature when dragging along this surface.



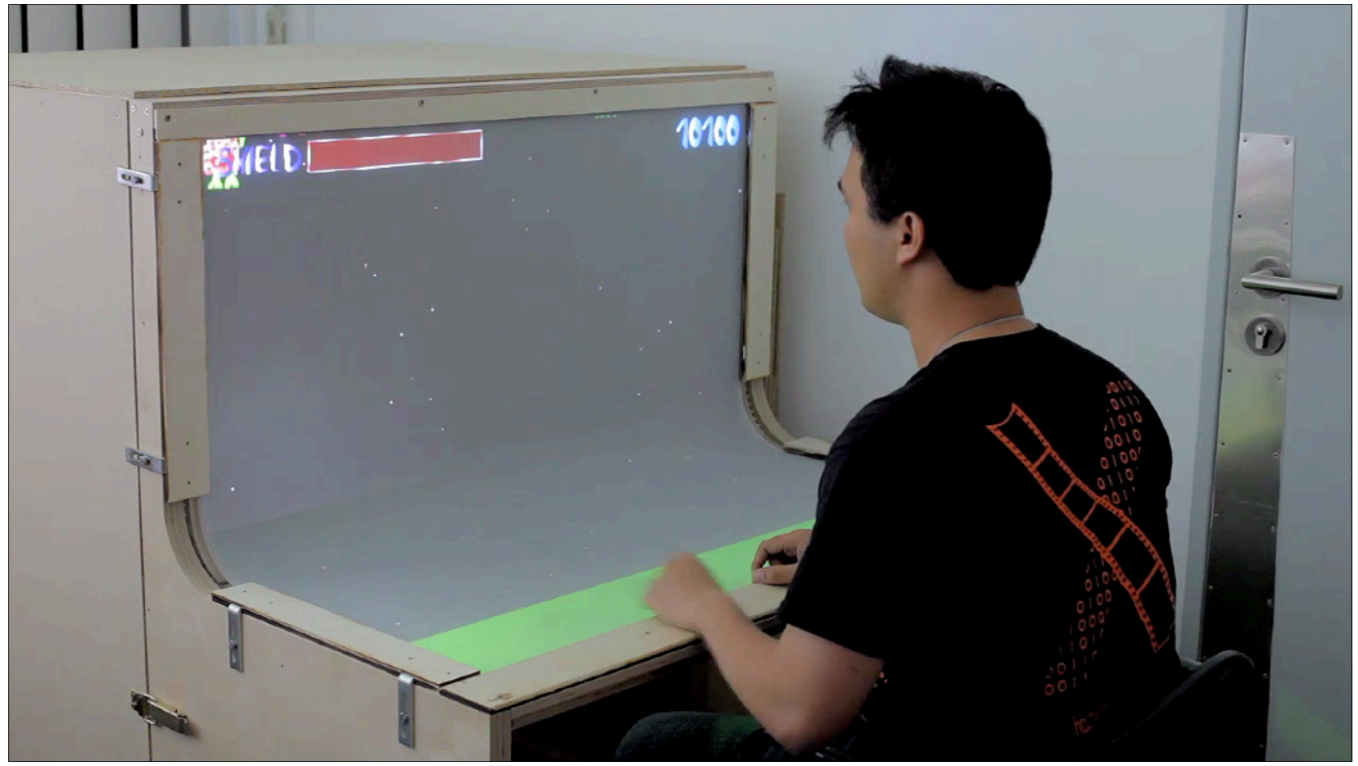
Users drag on a straight line down along the curvature and then move towards the target after leaving the concave area. It is assumed that this is done subconsciously to minimise dragging over the curved surface.



Additionally, user’s avoid body movements which feel uncomfortable. Thus you can see that the user does this wide dragging gesture with an extended arm instead of bending the arm more to move more directly to the target.

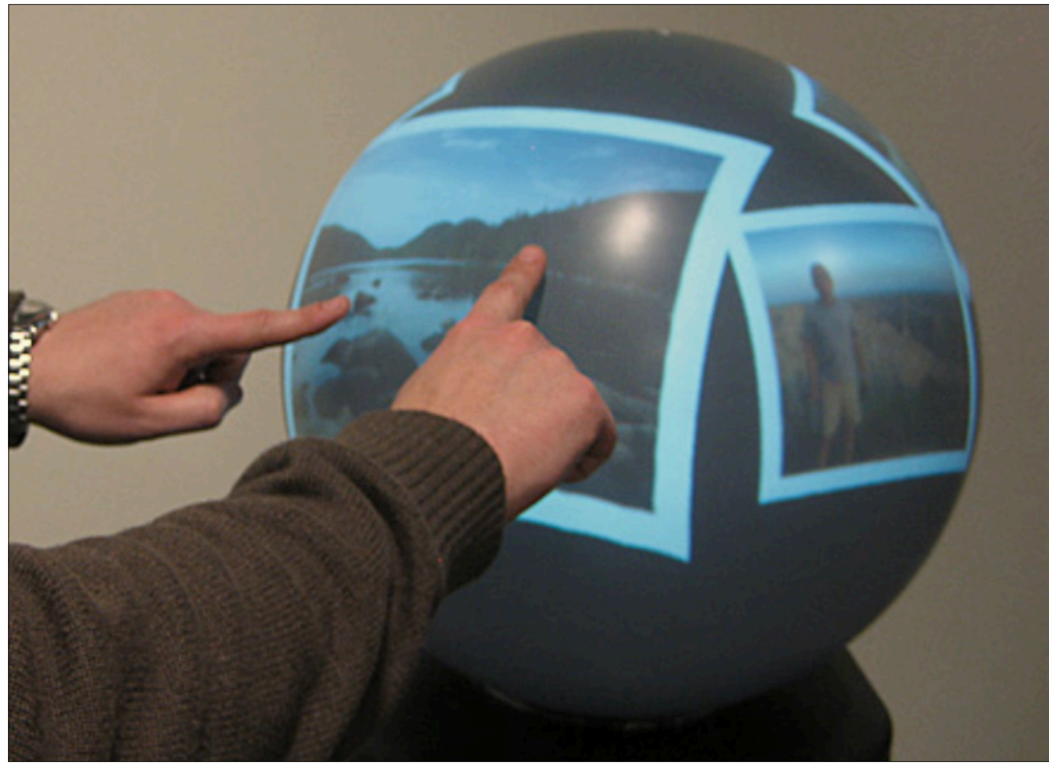


Having these two surfaces challenges user’s to use a 3D cognitive mapping instead of a 2D one which is used on a flat touch device. This makes aiming over the curve difficult at first.



- It is therefore preferred to aim straight on the curve.

Engaging due to a unique look



Sphere: Multi-Touch Interactions on a Spherical Display

Benko, Wilson, Balakrishnan

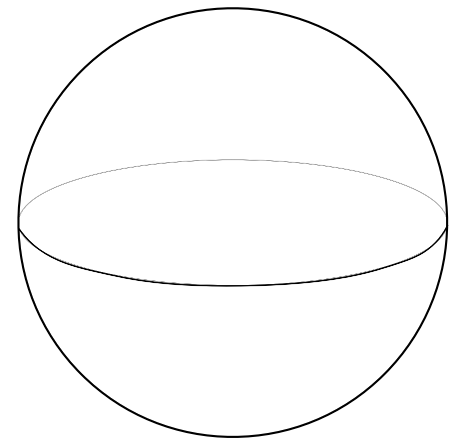
UIST'08

This paper contributes a spherical touch display. Additionally, it introduces basic characteristics and features of spherical displays.

The unique look and shape of this display seems to be compelling and engaging for groups of users.

Non-visible Hemisphere



Two people opposite to each other can work simultaneously without disturbing each other because one hemisphere is always not visible to a user. However, never is the entire screen visible to a user

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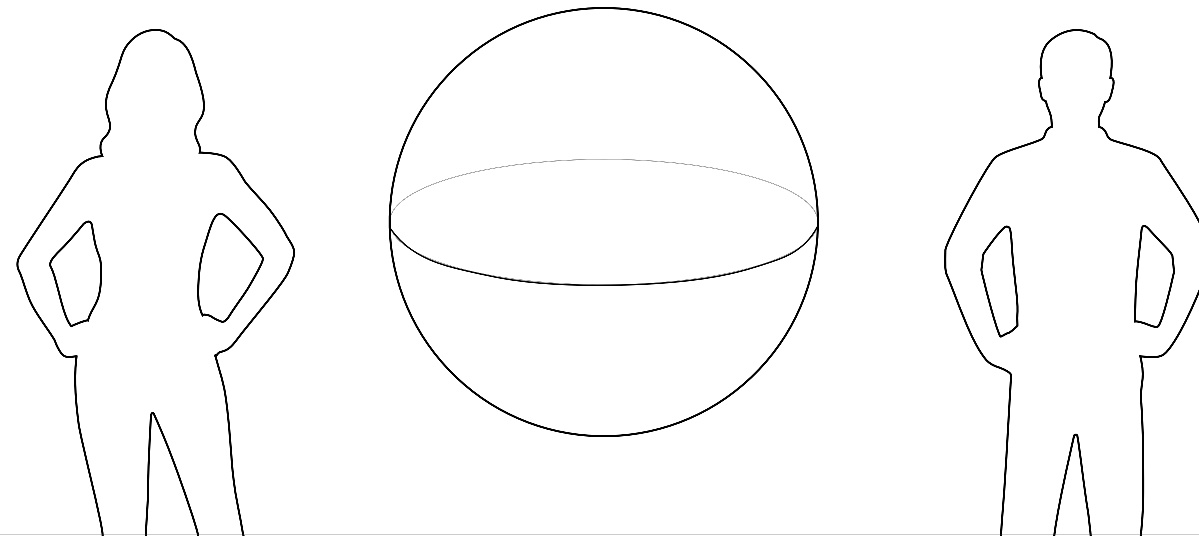

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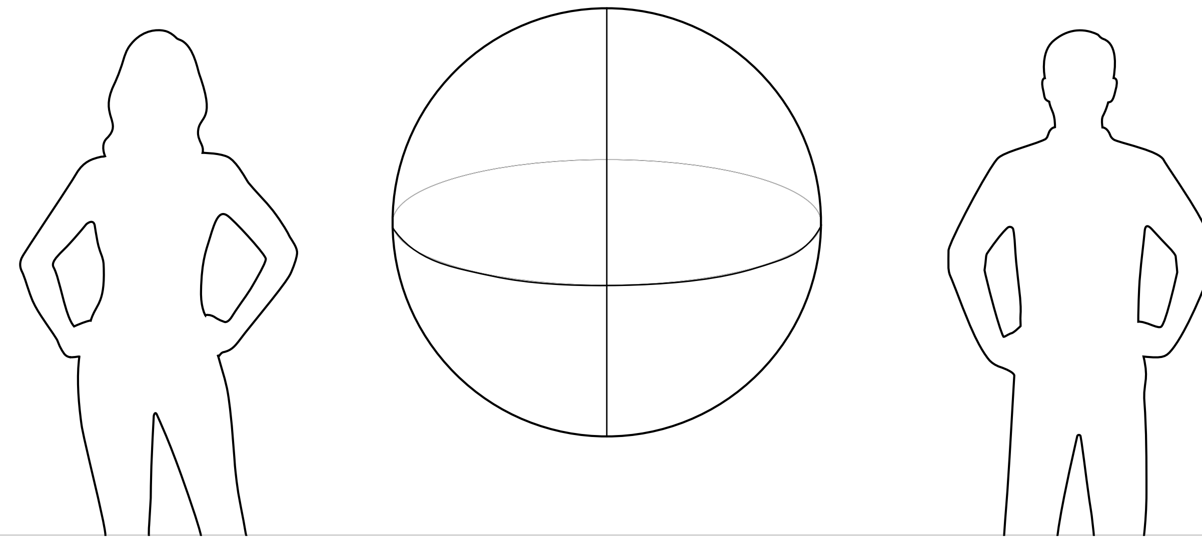

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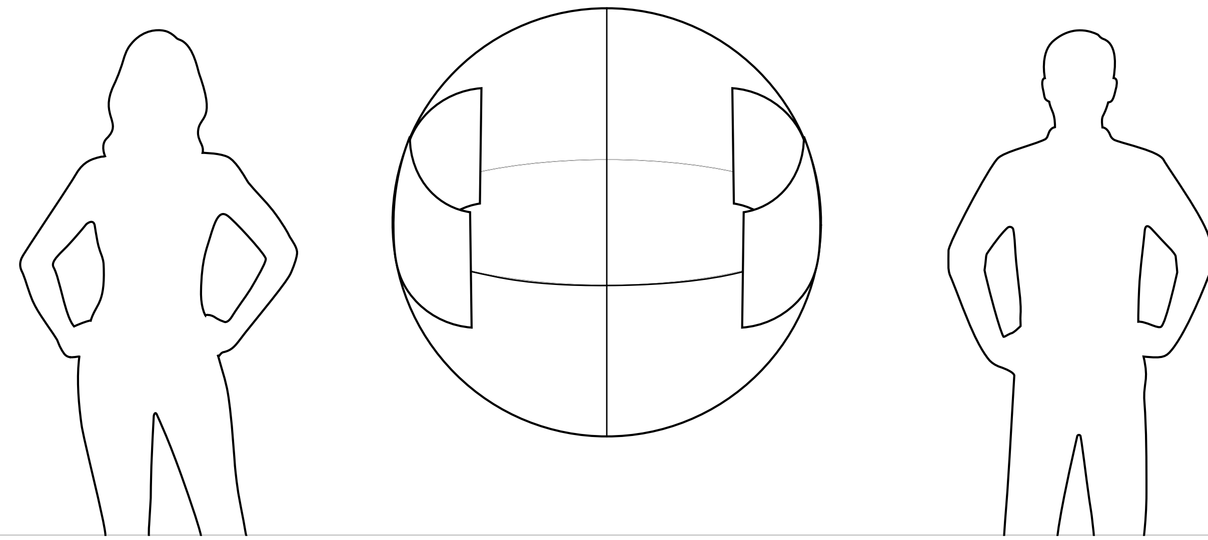

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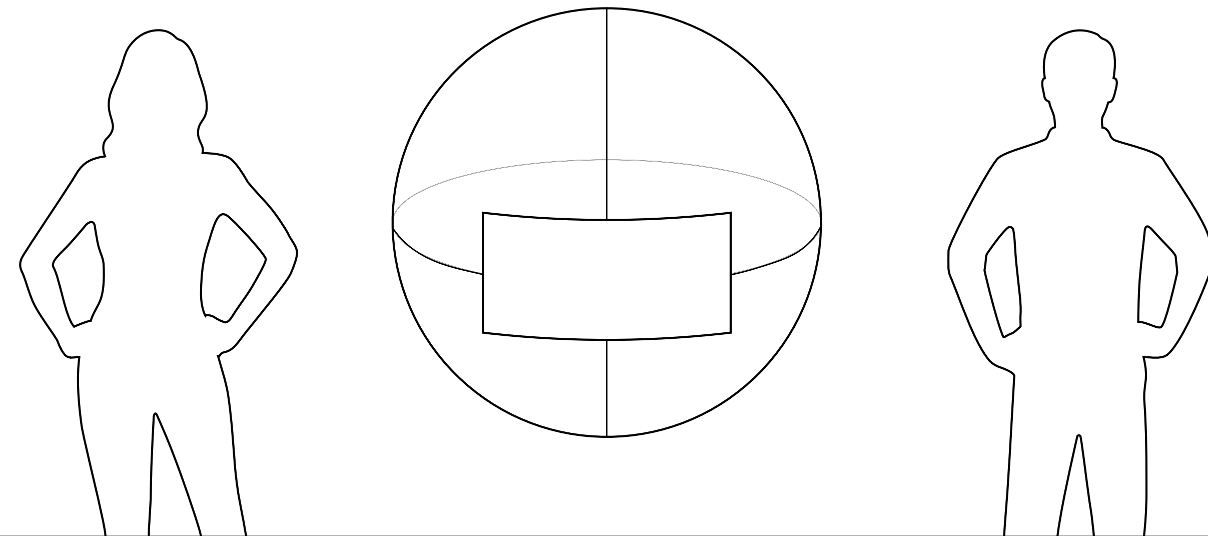
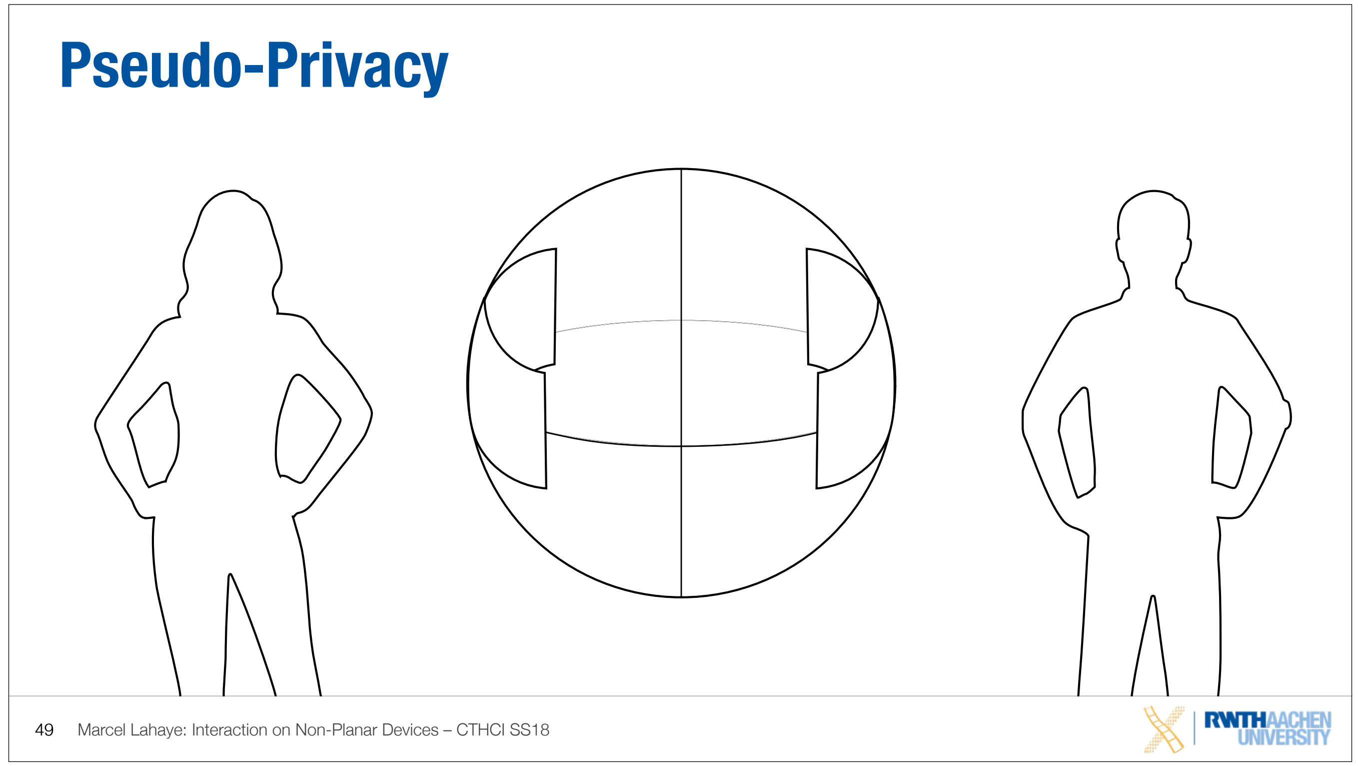
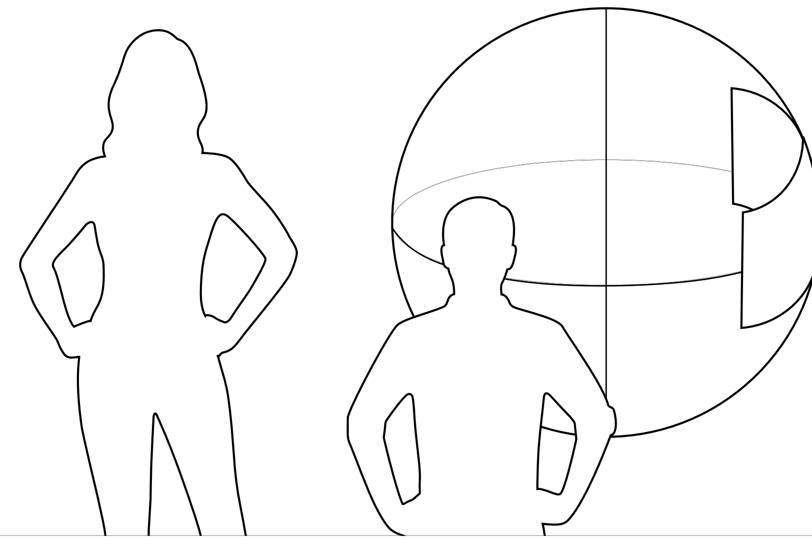


They can also work collaboratively at a screen space which is visible to both users.



The sphere can provide a pseudo-privacy due to the non-visible hemisphere. Users can react to the clear visible cue of a user approaching by hiding sensitive content.

Pseudo-Privacy



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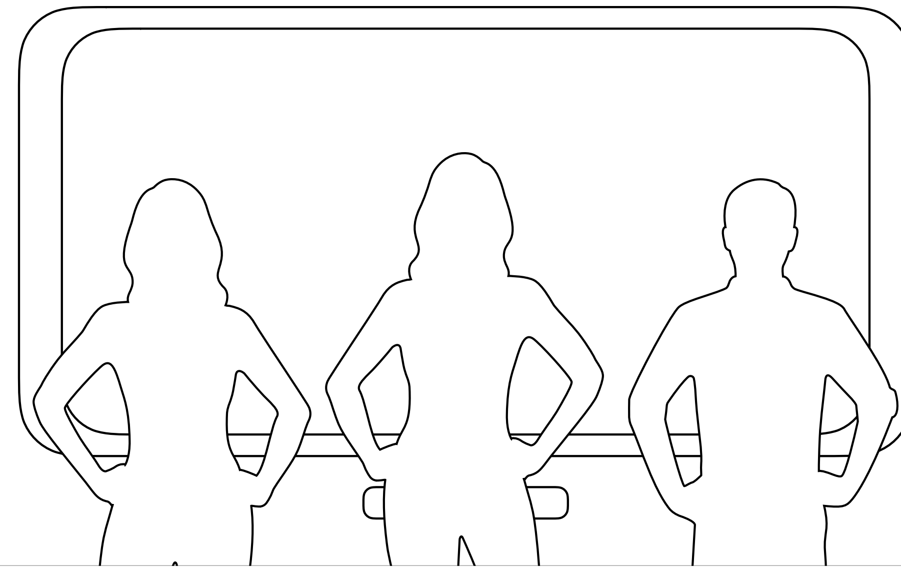
No Master User Position or Orientation



When sharing a planar display the user in the center has a larger interaction area than the other users.

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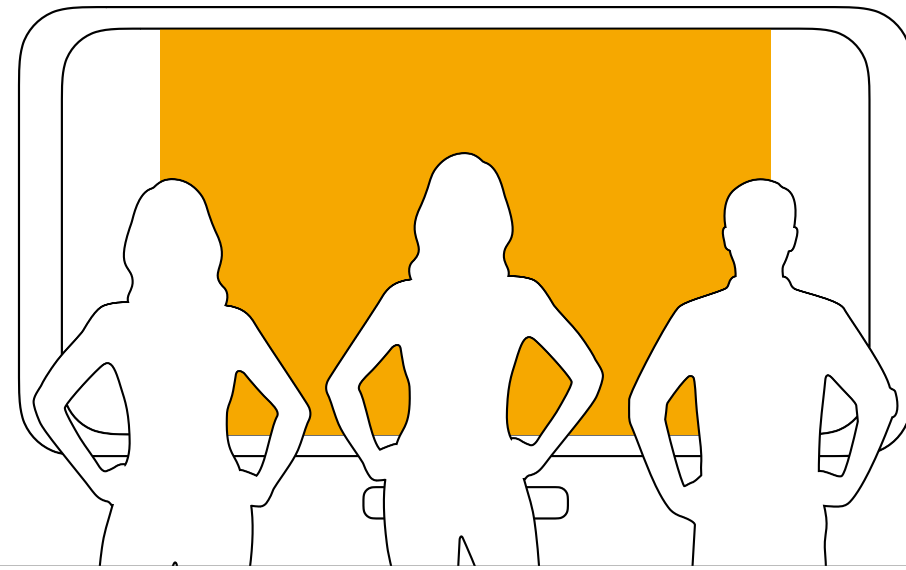

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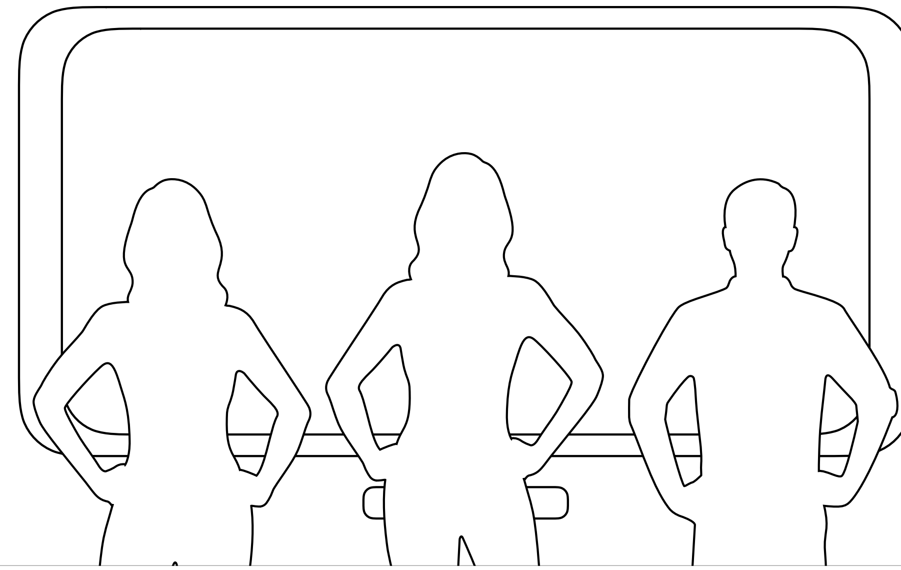

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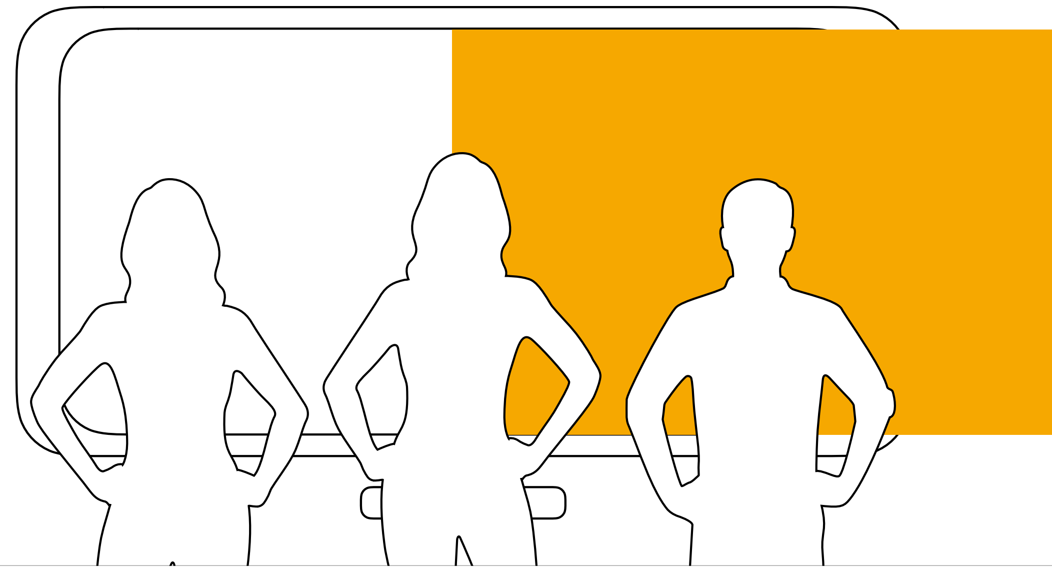

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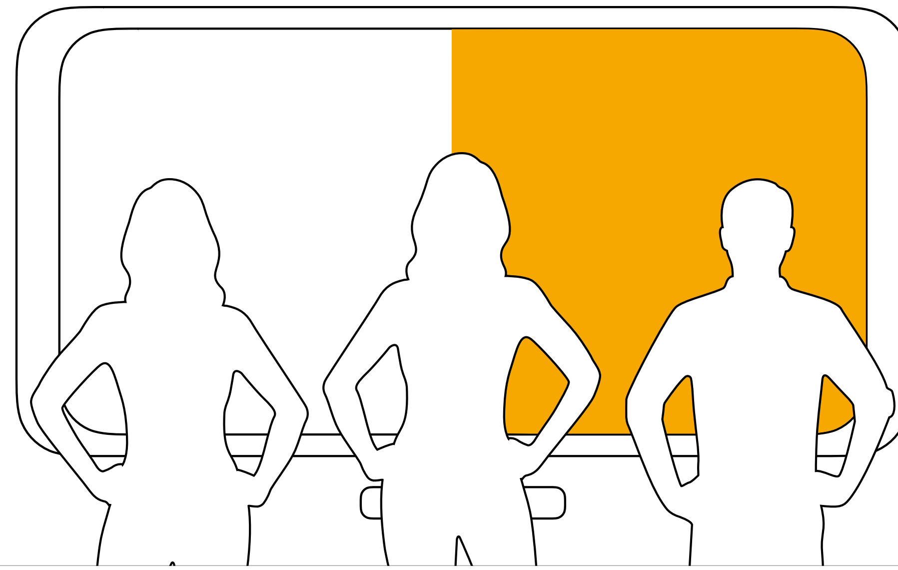

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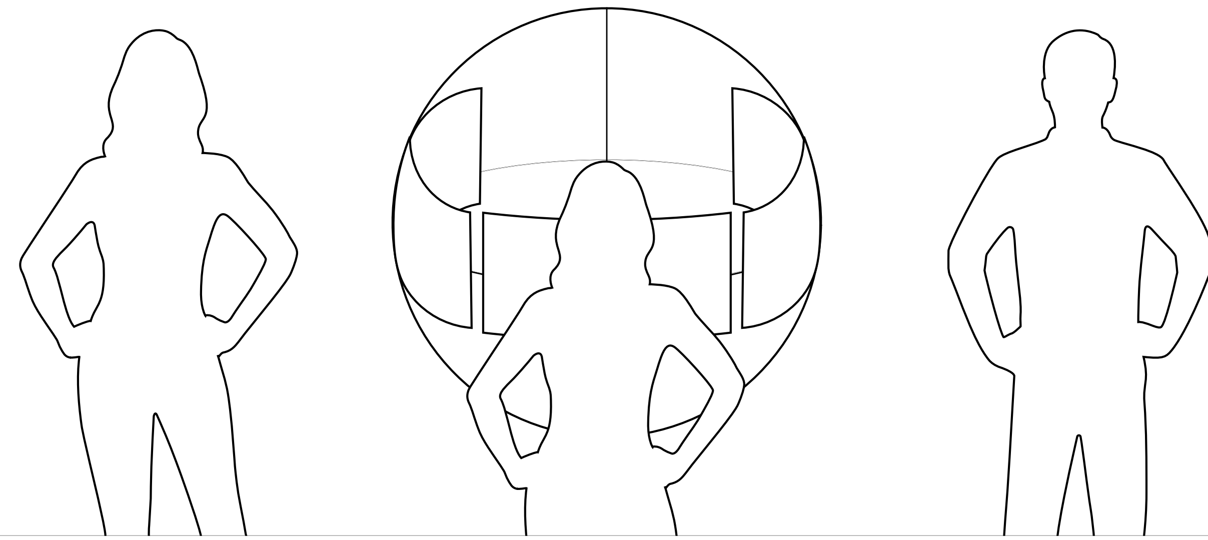

On a spherical display when evenly distributed around the sphere each user can access the same amount of space on the screen.

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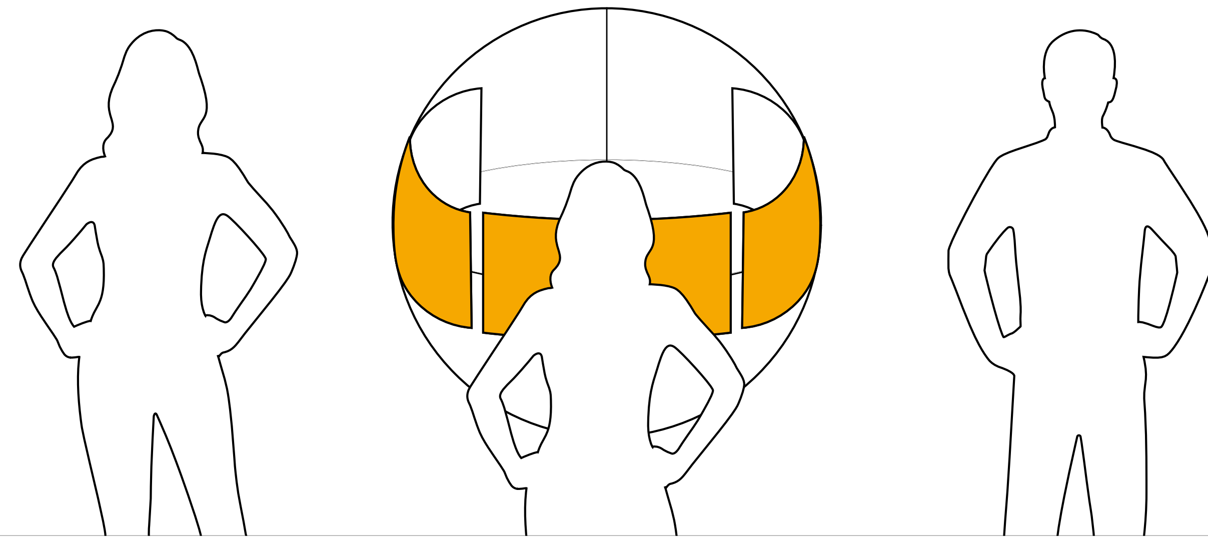

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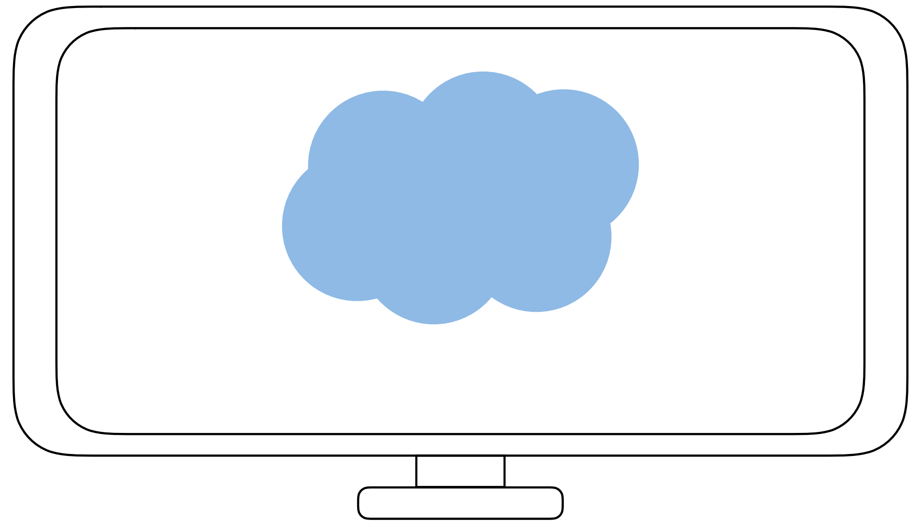
Visible Content Changes with Position and Height

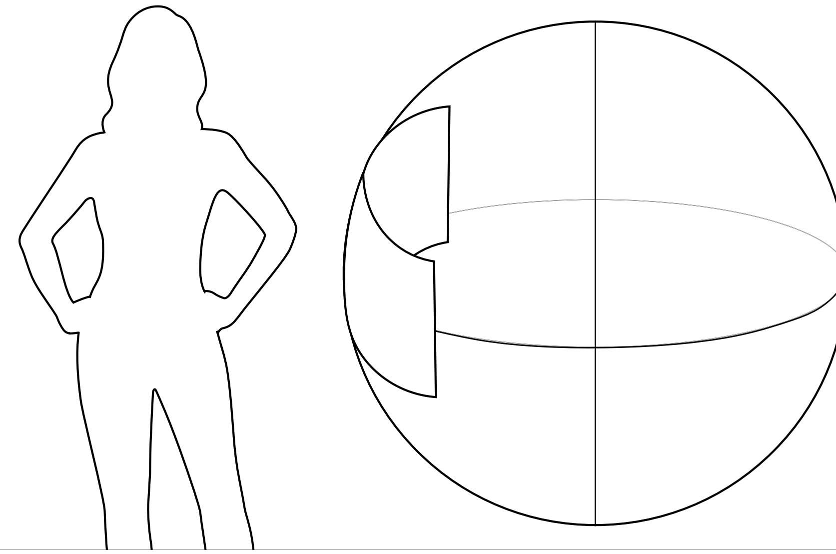


The content on a planar display does not adapt to the user's position (without any tracking). Content is only skewed when viewed from the side or not visible when standing at the back of the display.

Visible Content Changes with Position and Height

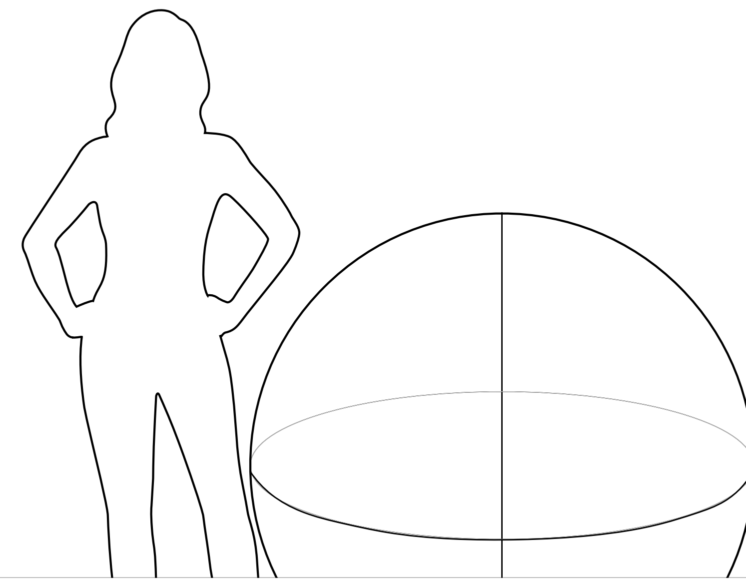
A spherical display provides users the possibility to move around the displayed content and see things on the backside which were not visible before.

Smooth Transition Between Vertical and Horizontal Surfaces



Similar to the concave BendDesk display the spherical display provides a smooth transition from working on a horizontal surface to working a vertical surface.

Smooth Transition Between Vertical and Horizontal Surfaces



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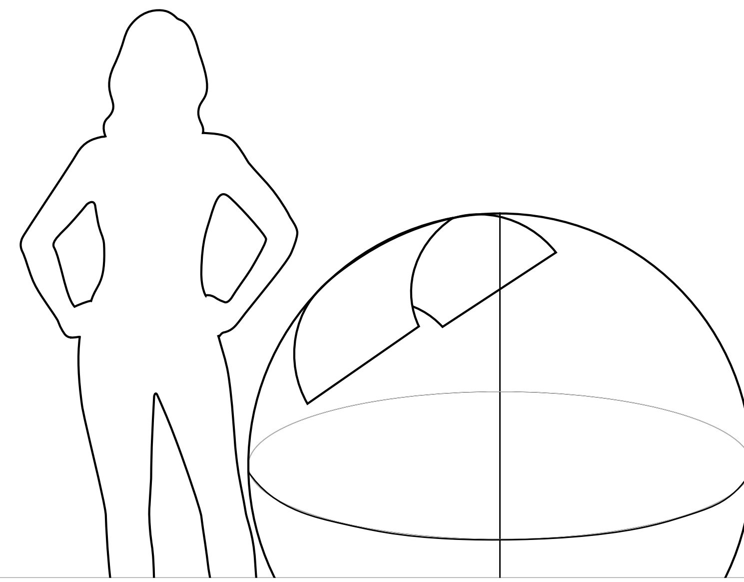

Borderless, but Finite Display

Classic planar displays work with a window metaphor which act like a window to the displayed content. You can move the content outside of the display borders or the other way around. This gives you the possibility to scroll over a possibly infinitely large content surface.

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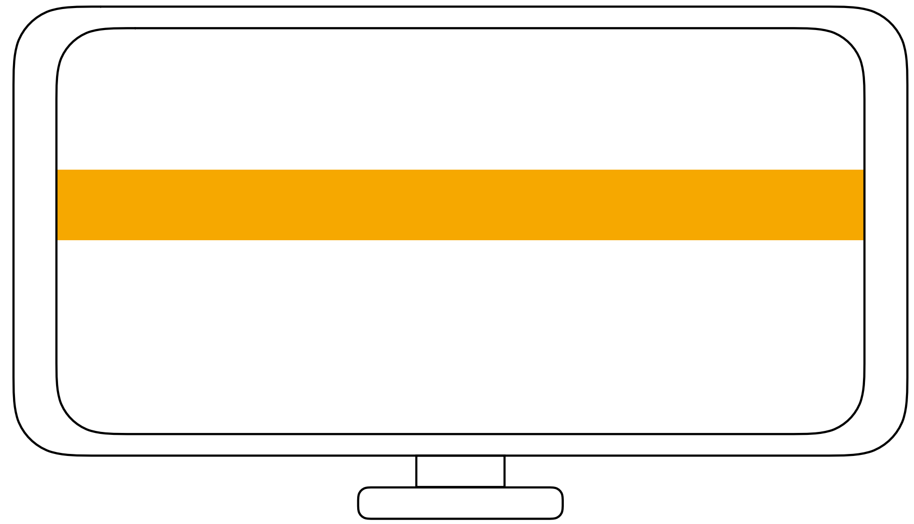

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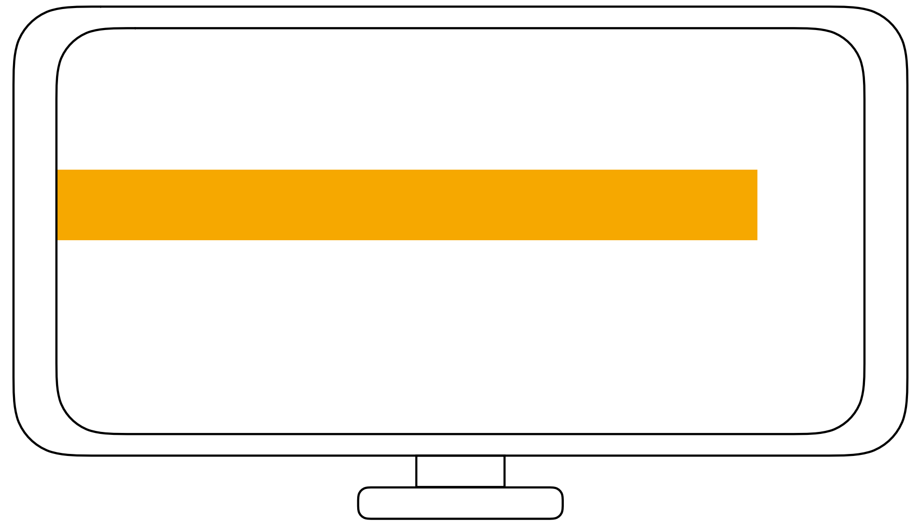

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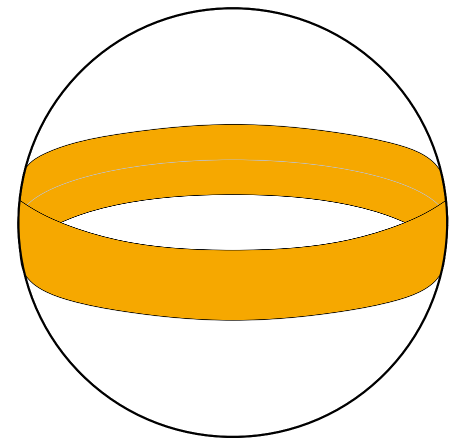

A spherical display however is borderless and can display a finite content. It is for example not possible to move content outside of the display without breaking the spherical metaphor.

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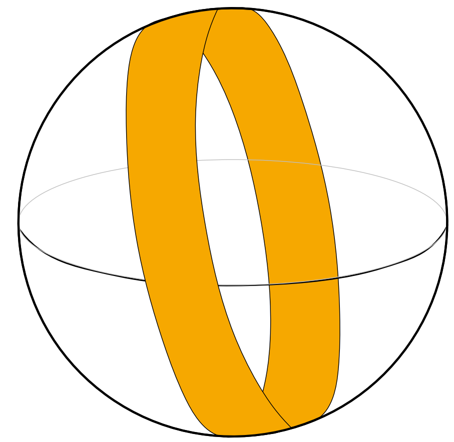

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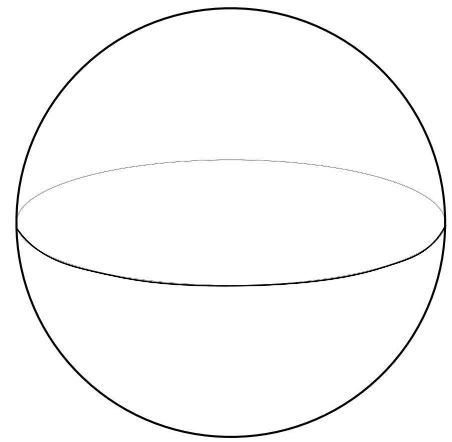
Natural Orientation Landmarks



A spherical display provides visual cues. The common ones are the north and south pole (top and bottom) and the equator line.

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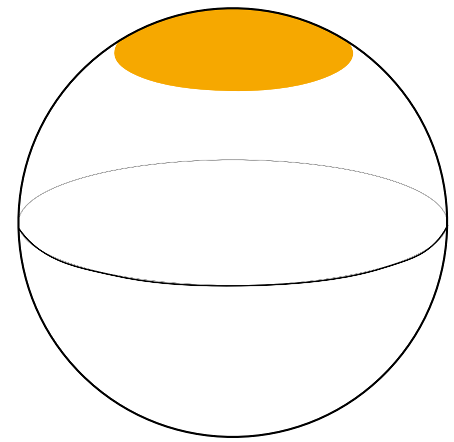

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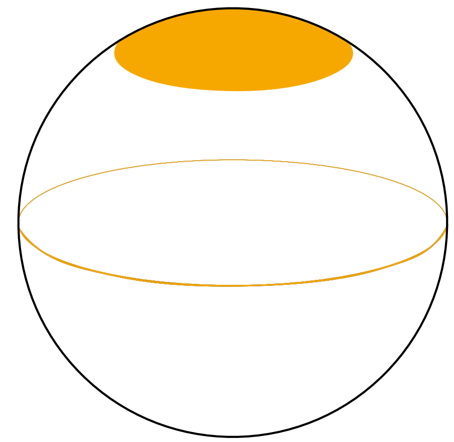

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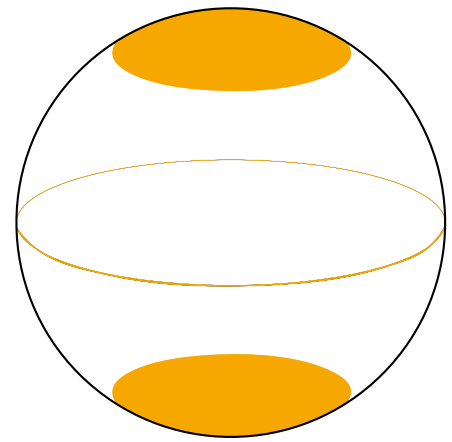

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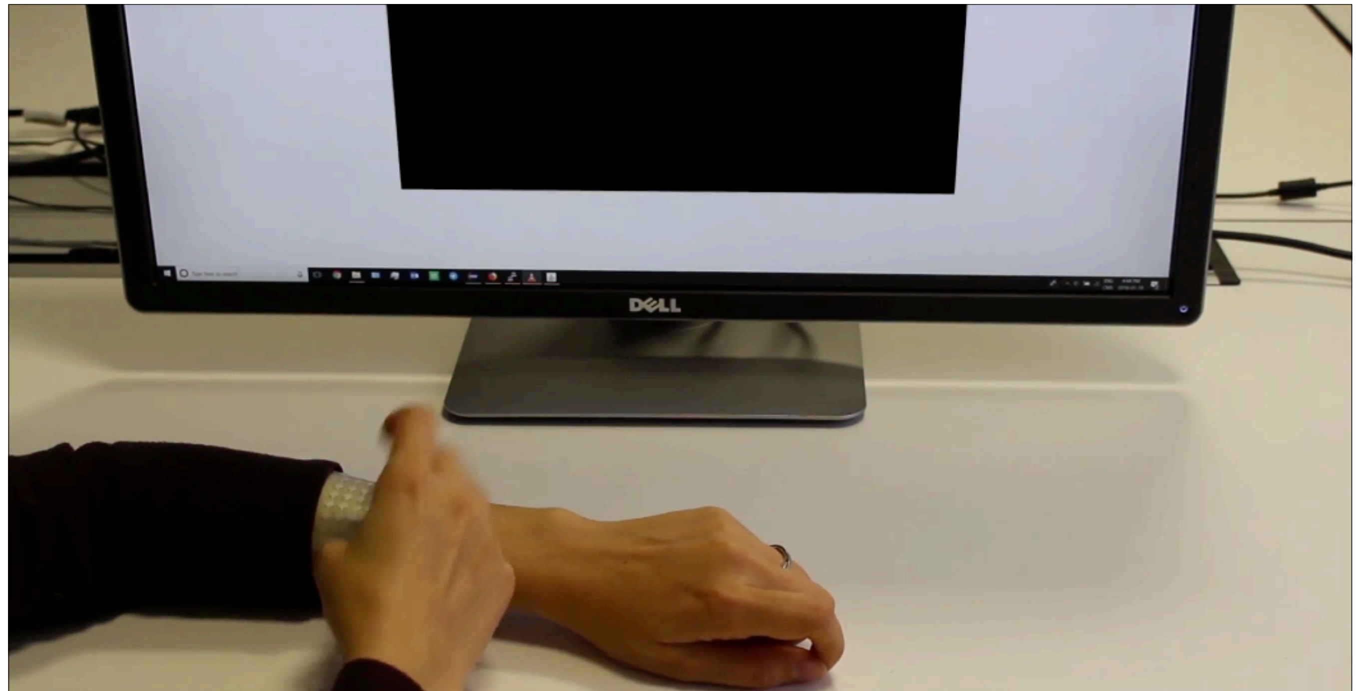
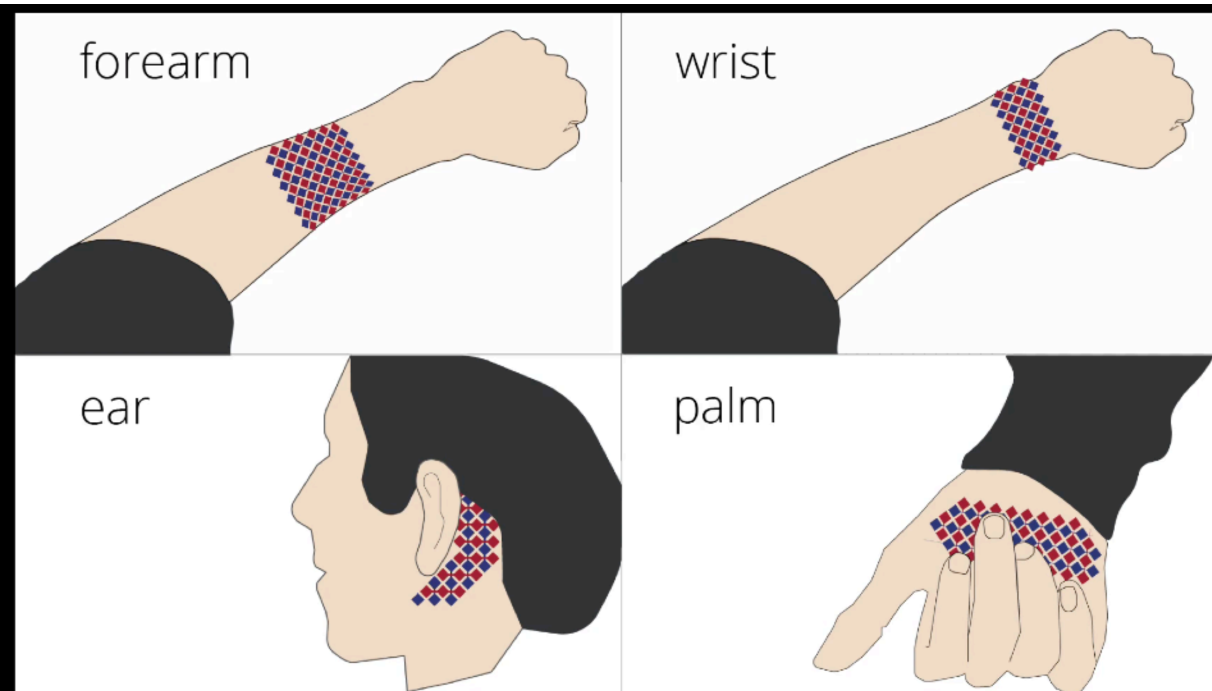
Adaptive due to a flexible design

From the papers abstract:
Existing skin worn sensors are restricted to single-touch input and limited by a low resolution. We present the first skin overlay that can capture high-resolution multi-touch input.



We present **Multi-Touch Skin,** the first skin overlay that enables high-resolution multi-touch sensing

Then the sensor is printed with inkjet or screen printing



Four application examples illustrate the novel form factors and sensing capacities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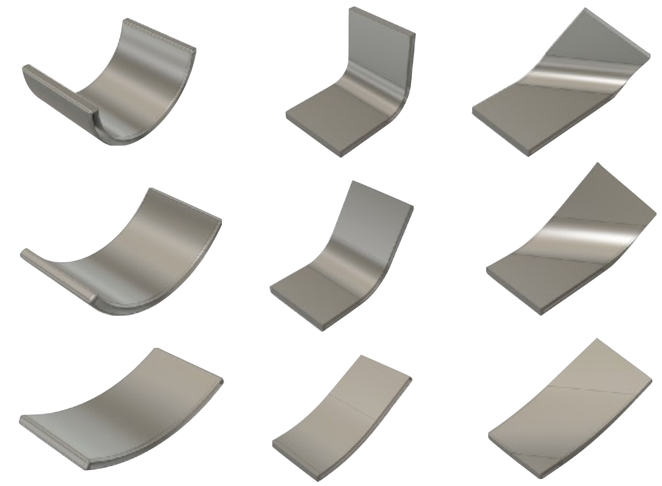
Interested to join ongoing research in this area?

Master Thesis about
Curved Mobile
Touchscreens

Contact
Marcel Lahaye
lahaye@cs.rwth-aachen.de



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