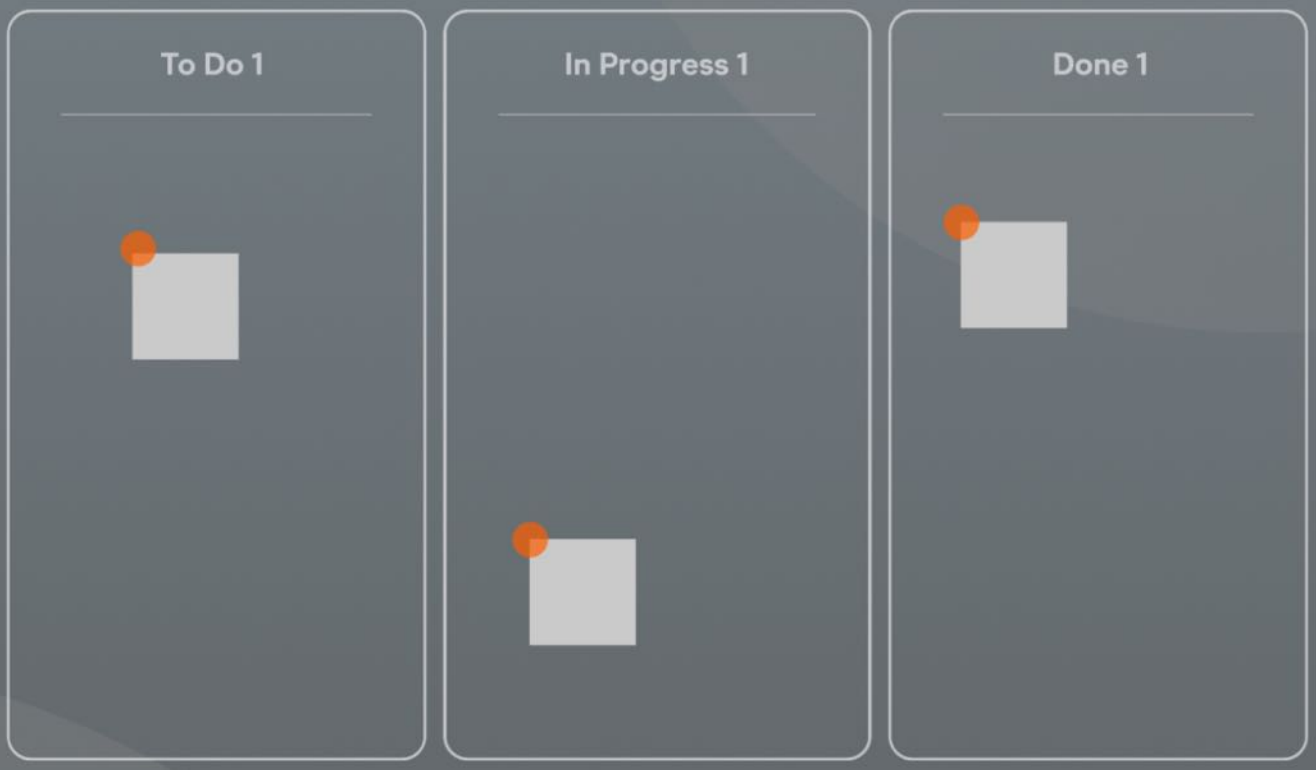

Tangible Kanban Board

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Abstract

For this project we explored the possibility of converting a real pinboard into a tangible interface with digitally extended functionality.
The resulting hybrid pinboard allows for creating and manipulating digital notes with real tangible magnets on the magnetic board. We developed two different approaches to the interaction with the board, which were compared in the user study. This helped us evaluate the usability of two versions and the preferred interaction type amongst users. The result has shown the preference towards the more simplistic, intuitive and stable interactions.
Overall, the study has shown the strong potential for the future development of the idea, with possibility to be used in real-life environments like offices and universities.
A video demo of the project can be accessed via following link:
https://youtu.be/LQe2ZUPBLQc

Our Motivation

Is there a way to improve traditional task boards with a digital tangible experience?

In many areas of study and work, teams use whiteboards and pinboards for collaboration. Such traditional tools, although functional, engaging and fun, come with some limitations. For example, paper task notes, once created, can't be edited later. They also can't be scaled for better visibility or saved digitally for a later use.

Is there a way to address those issues and enrich the teamwork experience?

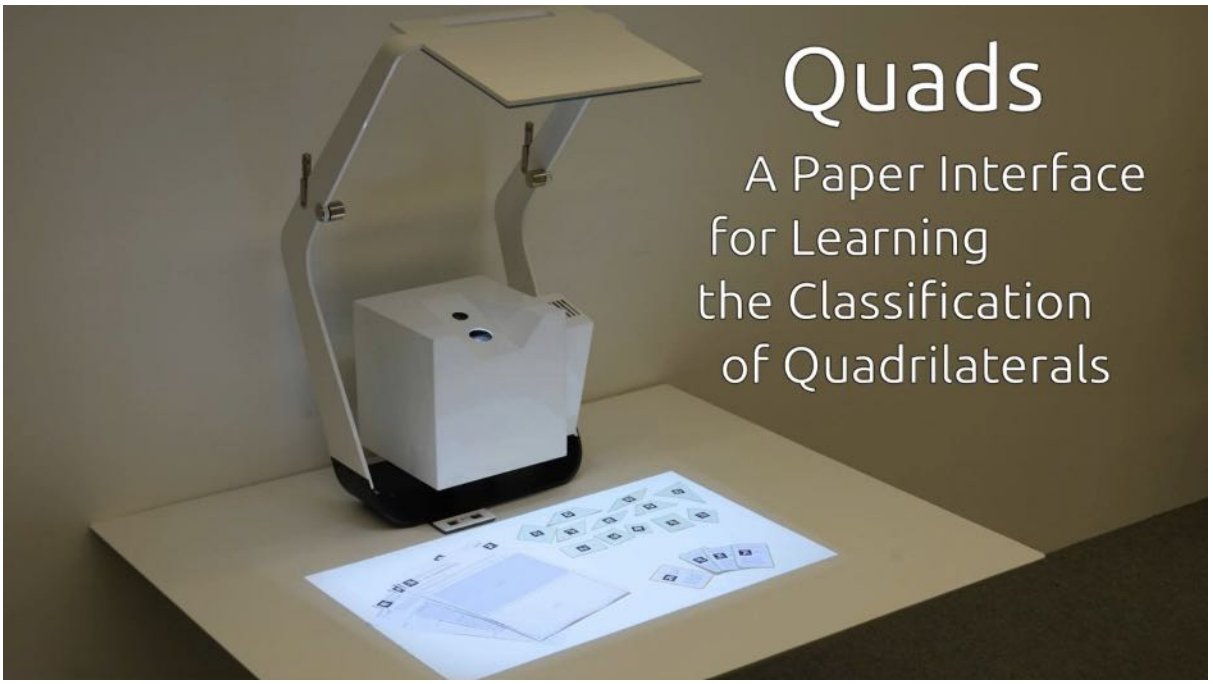
We came up with an idea of the Tangible Kanban Board to research exactly this question. Unlike the traditional board, the digitally augmented one could be easily editable, store and transfer data and provide users with additional controls over the created notes.

The main goal of the project was to explore the advantages and limitations of such a hybrid alternative to a traditional board and expand the possible interaction scenarios for tangible board controls.

Related Work

What has been explored before?

The concept of a hybrid tangible board is inspired by *Tangible Paper Interfaces: Interpreting Pupils' Manipulations, 2012 by Bonnard, Jermann, Legge, Kaplan, Dillenbourg*. This project focuses on providing the additional layer of information to the tracked paper shapes used for geometry learning. That inspired us to use the tracked position of the object to define its relations to others, as well as an idea of using a beamer to create a digital layer of our prototype.



Tangible Paper Interfaces: Interpreting Pupils' Manipulations

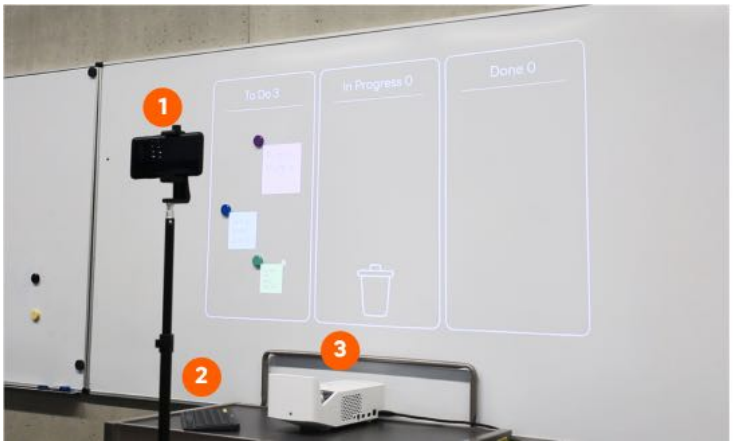
Another source of inspiration was a project called *Marble Answering Machine by Durell Bishop, 1992*, which turns the process of reviewing recorded calls into a tangible experience. In the project marbles represent calls and can be sorted, categorized and cleared by placing them in the different areas of the answering machine. The same concept of adding the meaning to the tangible position is used in our project, as well as the distinct colors of tangibles for better recognition.

Concept

How does the prototype work?

Setup

Our hybrid tangible board uses a real magnetic whiteboard as a base, but extends it with a projected canvas. To create a note, a user needs to place a magnet in one of three areas of the Kanban board (To Do, In Progress, Done) and type in the text with the keyboard available on the stand in front of the board.
The position of the magnet is then tracked by the camera installed in front of the board. The camera recognises the colors of the magnets and sends the color and position values to the processing laptop with the Touchdesigner software running on it. Digital notes are then projected to the corresponding position of each magnet.



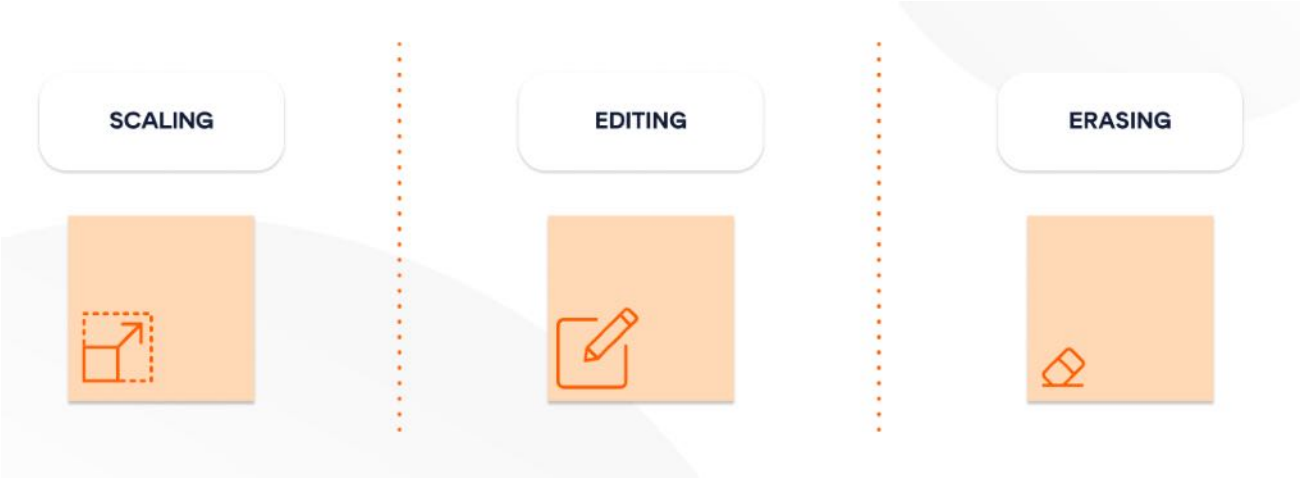
The Tangible Kanban Board setup

Such a setup allows to preserve the feeling of the interaction with a real board, but adds extra possibilities to it. For example, the board tracks the amount of tasks in each area and updates the corresponding number automatically. Additionally, an icon is displayed next to each note, showing its status (“To do”, “In progress”, “Done”).

Interactions

When developing the prototype interactions, we focused on the main properties the traditional board has, and on the ways we could enhance them.

As such, we chose possibilities to create, edit, prioritize (by size) and clear notes on the board as the functionality available to the user.



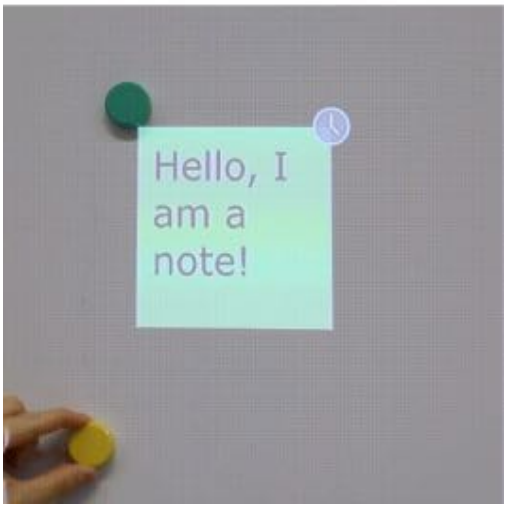
Functions of the prototype

As a concept implies new ways and possibilities to access these functions, we developed two interaction variants for each interaction type.

Scaling:

Moving the notes up and down

Scaling with an extra magnet

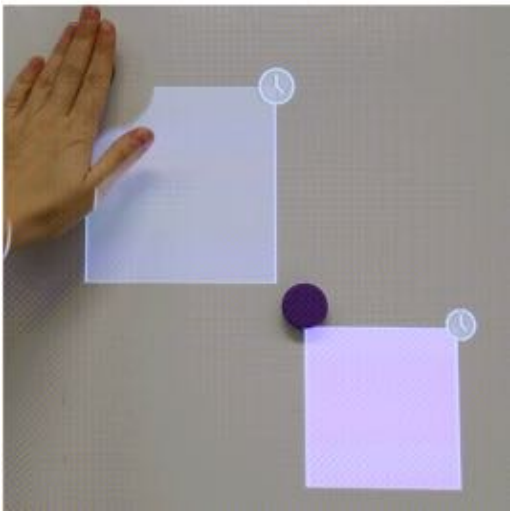


On the left: user needs to move the notes up and down the board, which would change the note size based on the ***y*** *axis* position on the board.

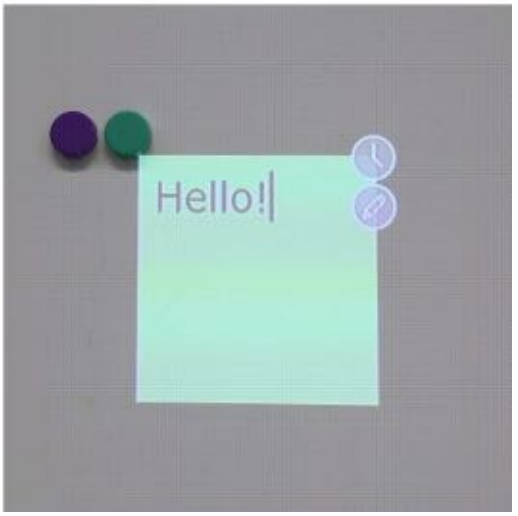
On the right: user needs to place a special magnet (yellow) next to the target note, and move it up and down the board to scale

Editing:

Editing with a tap



Editing with an extra magnet



On the left: user needs to tap the note with a palm to enter the Edit mode

On the right: user needs to put an extra magnet (purple) closely on the left side of the target one to enter the Edit mode.

Erasing:

Erasing with a trashbin

Erasing with shaking the note

On the left: user needs to put the note into the trash bin to erase it.

On the right: user needs to shake the note left and right to erase its content.

Implementation

Hardware

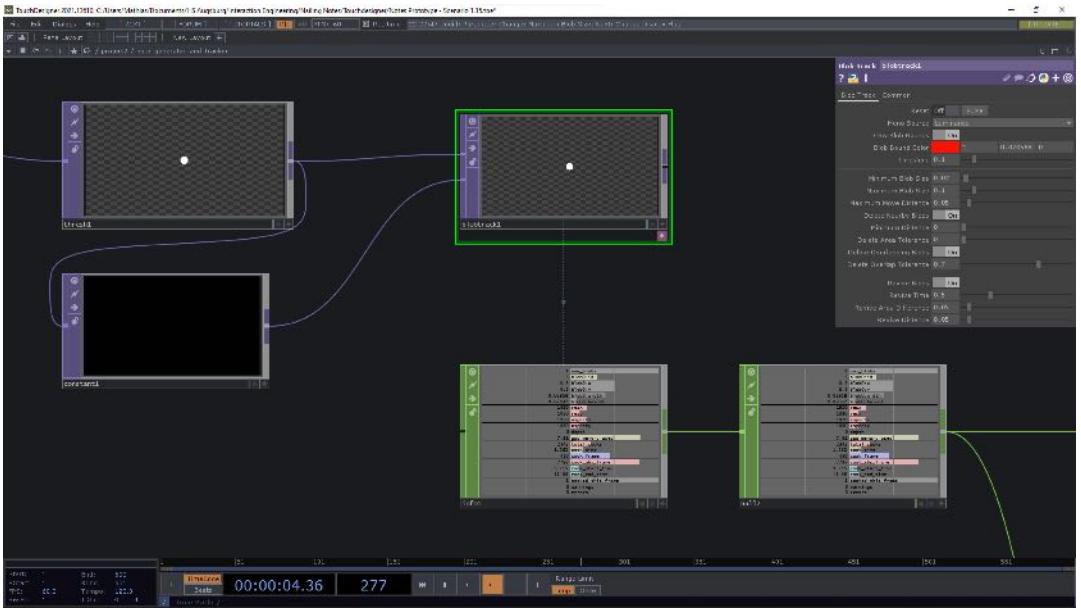
For the projection of the tasks and the interface, we used an Ultra-Short Throw projector by LG. Since we faced a lot of problems due to occlusion and shadow casting when we used traditional beamers, we started to look for alternatives. This kind of projectors use a special lens that projects the image onto a mirror, which means, they can produce a very large image with minimal distance to the wall or in our case, a Whiteboard.
We connected this projector to a Laptop which outputs the interface and the tracked tasks.
To track the magnets on the Whiteboard we decided to use an Android Smartphone, where we start the application DroidCam to send the live stream of the phone camera to the Laptop.
A bluetooth keyboard is used for the text input of the user.

Software

All image processing, the Interface and output is done using the software Touchdesigner.

Magnet recognition

In order to properly detect and track one of the colored magnets on the whiteboard, we first reduce all colors that we don't want to detect, with a process called RGB Keying. Next, we use a node called Blob Tack to obtain the position of the object (magnet). Here we also reduce the size threshold of the blob detection, in order to mitigate false detection. Using the position of the blob, we assign a text field with a slight offset. That way, the text field is projected next to the magnet.



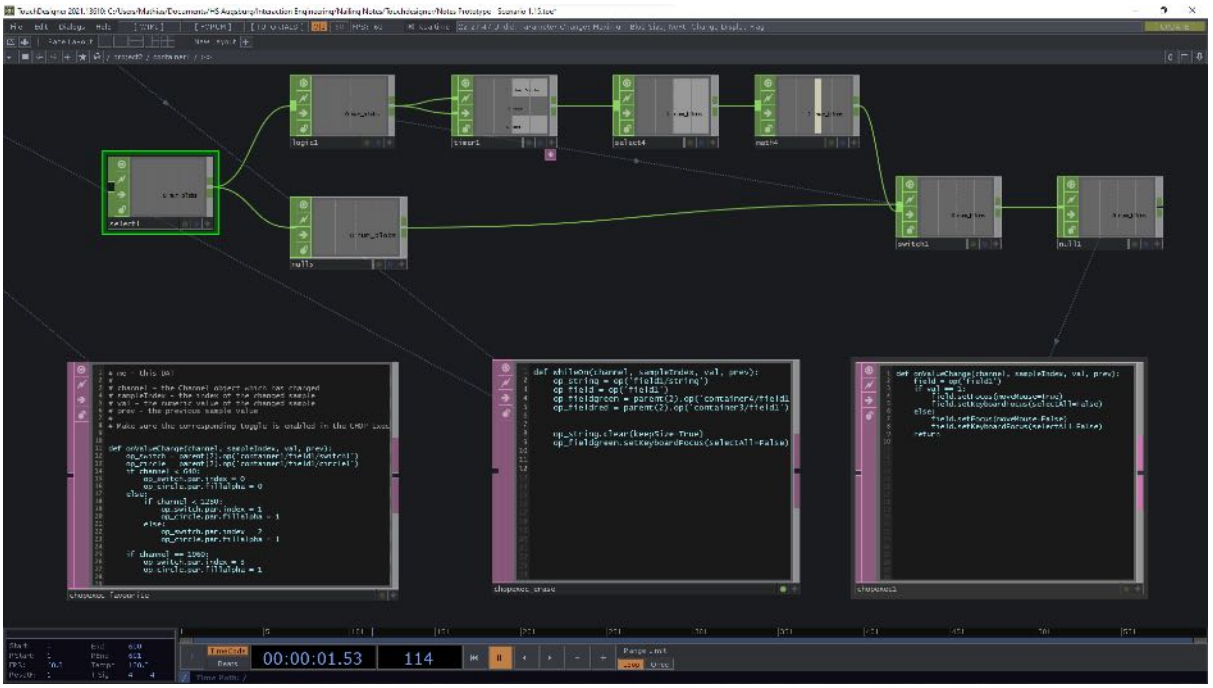
The blob tracking network used for note positioning

We then use this procedure to detect and track all other magnets with different colors and assign to them a unique text field.

Interaction Principles

For the scaling, editing and erasing features we use Python scripting in Touchdesigner.

For example, we can get information if a blob is newly detected or not and if it is, we tell Touchdesigner to switch the focus of the mouse to this blobs' text field. This process comes in handy, when the user is tapping, and therefore occluding, the magnet with their hand. When the user is removing the hand from the magnet again, the magnet is newly detected and the focus shifts to its field. There are also little interface elements that visualize that this field is now in focus (blinking outline, edit icon).

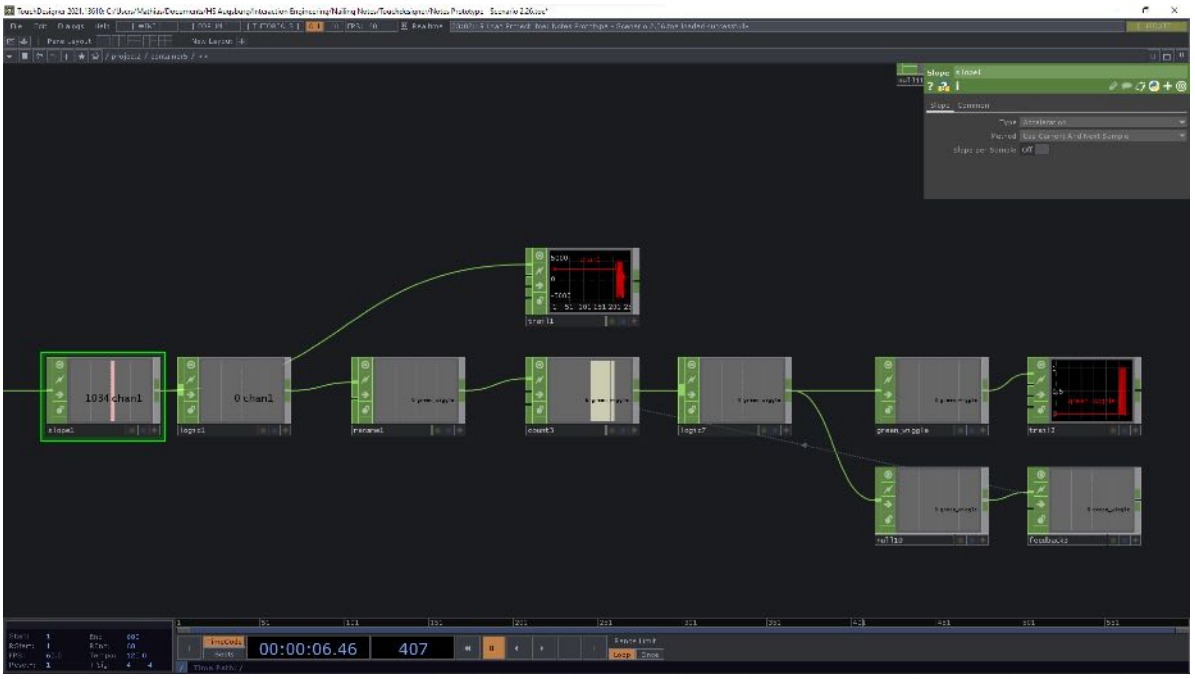


The network used for note focusing

For most features we use the position information to adjust certain parameters. Based on the ***y*** axis position of the magnet, the text field is being resized. There is also a small area at the position of the trash can, that clears the text in the field, if the magnet is positioned in it.

In order to resize a task with a second magnet, we compare the distance of the magnet that we want to scale to the scale magnet. Based on the amount of the distance, the field is either growing or shrinking.

One of the more interesting techniques we used to clear the text of a field using shaking, is to detect and analyze the speed of movement of a blob. Using the *Slope* node we can detect the acceleration of a magnet and we can also count the number of accelerations within a certain range. Here we say, for example, if the acceleration of a blob is within 4000 and 8000, activate a trigger.



The network used for clearing by shaking

Next we activate this trigger only if we hit this range ten times subsequently. And if that trigger is activated, the text field which is assigned to exactly this blob should get cleared.

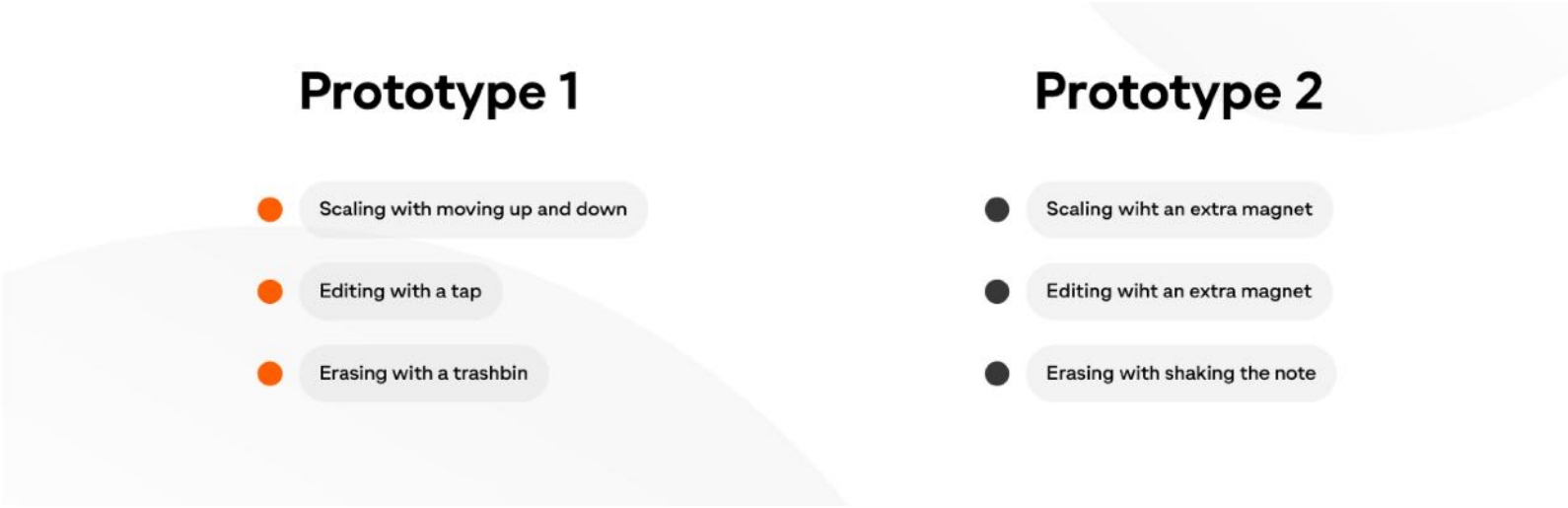
All in all, Touchdesigner turned out to be a good environment to develop this prototype. Although sometimes, developing features that should have been quite easy to implement, like changing the focus of a field or clearing the text, didn't always seem extremely intuitive at first sight, but after some tinkering and research, most problems could be resolved.

Evaluation

User Study

What did we learn from our prototype?

The main aim of our evaluation was to figure out the preferences in the interaction methods we developed. We also were interested in the overall intuitiveness of methods as well as an overall rating for the board.
To evaluate those features, we developed 2 different prototype versions for a within-subject test.



Prototype versions for the test

The test group consisted of 11 Bachelor and Master students of the university. During the test, participants were introduced to the functionality of the board first, and then asked to put 3 note magnets on the board and use all 3 features (scaling, editing, erasing) of each prototype.
The order of prototypes was always the same: 1st, and then the 2nd one.
When testing the functions, users were asked to use the feature at least 3 times on different notes to get familiar with the action.

User test setup

After completing the task, users were asked to fill in the questionnaire (Google Forms) and pick 5 out of 50 product reaction cards (physical paper cards) with descriptive adjectives, such as fun/ innovative/ boring/ sophisticated/ simple, etc. Our questionnaire included 21 questions, starting with yes/no questions about the previous experience with tangible interfaces and kanban boards. The main group of questions had the same structure and compared the interaction techniques (scaling, editing, erasing):

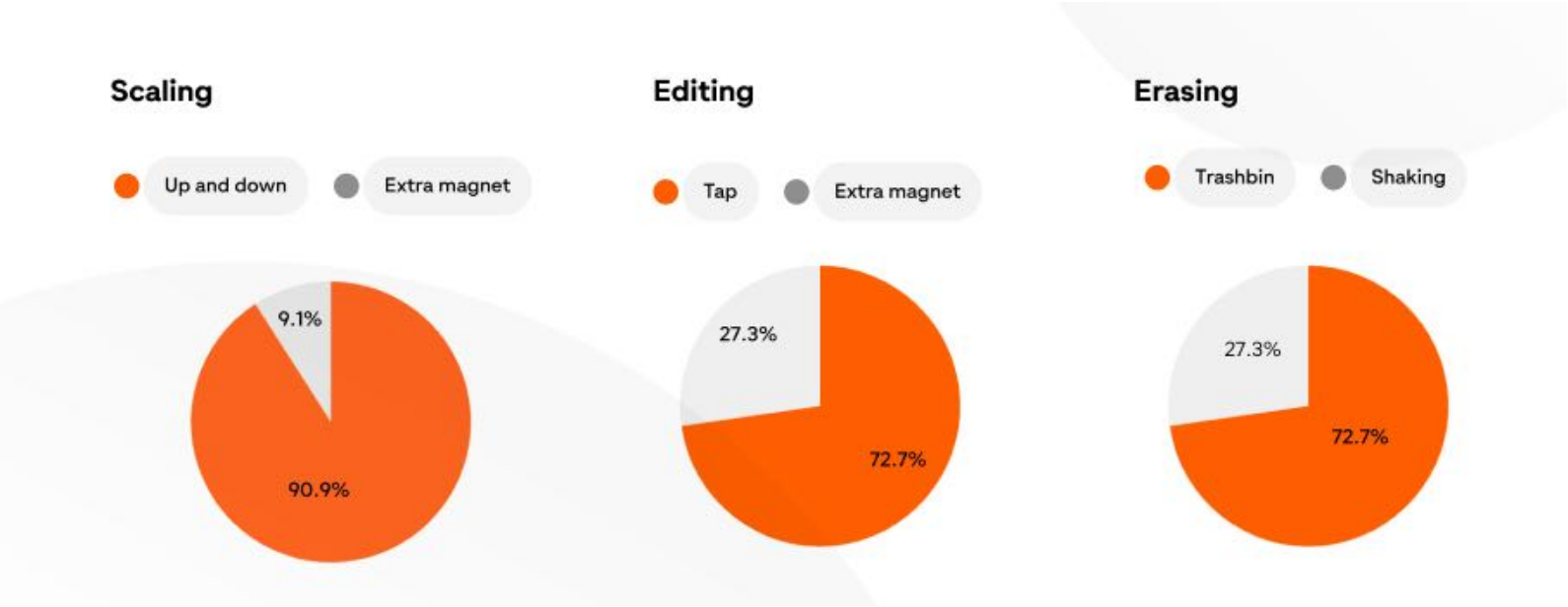
1. How intuitive was the technique? (Likert scale from 1 to 5)
2. What is your preference, if any? (1, 2 or no preference)
3. What is the reason for your choice? (open question)

We also asked about the technical issues our users faced, if any, to analyze the correlation between the feature stability and user preferences.

As for the final question, we asked how likely the user would be to use our board in general (Likert scale from 1 to 5) with an option to elaborate the choice with a short text.

Results

Despite the relatively small number of participants, the test has shown a strong tendency towards the first prototype with more simplistic and conventional interactions.



User test results. In orange - prototype 1, in gray - prototype 2

With the data from the open questions about techniques, we also learned the reasons behind the user choices.

Scaling	Editing	Erasing
1, it worked more reliably	Reliable, gives reference	Trashcan does not need an explanation, intuitive
1, because you do not need an extra magnet	You need less magnets	more obvious
1, because it is more natural	1, Easier, less magnets	It is easier to handle
1, the scale magnet was unstable	1, no extra magnet needed, tapping is reliable	1, the second one did not work
1, it feels easier	1, you do not need an extra magnet	1, it worked more reliable
1, because it does not need an extra magnet	1, felt more natural	Because 1 is more intuitive
1, felt more natural		1, trashbin is deleting
1, with extra magnet the size resets		

Most of the users were selecting the faster, more stable and intuitive gestures. Contributing to the decision could be the fact that Prototype 1 was working more reliably and had less technical issues, whereas Prototype 2 required users to learn the exact way to perform functions and thus was prone to errors.
For example, many users struggled with finding the right way to shake the note to clear it. This has also added to the user preferences and can be seen in the open question responses.
Additionally, we discovered some repetitive patterns in the users' behavior when conducting the test:

1. When asked to tap the magnet with a note to edit it, users mostly tapped directly on the projection of the note, and not on the physical magnet. It can be seen as an additional proof that the users seek the most direct way to interact with items.
2. In the scenario with an extra magnet as an edit mode controller, users needed to put the magnet away from the target note to confirm the input and exit the edit mode. However, users pressed Enter on the keyboard instead as they would do in a field input in PC interfaces. That demonstrates that some functions already have conventional actions derived from the computer interfaces and should be considered when developing interfaces with tangibles.

The most common appearing product experience cards were fun(5), innovative(3), unconventional(2) and fast(1).
Two users expressed the wish to use such a board in their work, if the technical setup was more compact.
Overall, the mean rating for the interaction experience reached **4,5/5** on the Likert scale from *Extremely Negative* to *Extremely Positive*.
This can be considered a good result, keeping in mind the fact that most of our users were not familiar with neither tangible interfaces nor kanban boards.

Conclusion

What have we learned?

The hybrid tangible kanban board proved to be an interesting concept that can be developed further and implemented in real-life scenarios like studying and working on the projects together in the office environment. The user tests have shown that such a board is likely to be used and can help people perform the same task as the traditional board does. There also was a clear preference towards simplicity in the interaction methods, which can be helpful when developing additional features.

However, there are a couple of issues to address and fields to improve in.

First, the tracking technology alternative should be considered, as the current state of the prototype imposes restrictions on the color that users have on them (clothing, accessories etc.)

Second, the interaction techniques can be improved to be more conventional for the users with PC usage experience.

In general the board has shown the strong potential to be a real working tool, with users addressing its advantages over the traditional board, such as:

- No confusion over the handwritten text
- Content is saved after the creation and can be accessed from other locations later
- Scaling possibilities make content more visible than traditional paper notes

Future work

With the user feedback given to the project, several functions and improvements can be addressed in the future, such as:

- Special team member identificators. It can be another tangible that helps to understand the authorship of the note or task during the collaboration.
- Additional interaction methods research. As there are already some conventions in the touch and gesture interfaces, next versions of the board could include more traditional ways of accessing the functions, such as pinching the note for scaling, or tapping the note itself instead of the magnet for editing.
- a possibility to transfer the notes content to a web-client, mirroring the real-life action to multiple devices of the team.
- A possibility to convert handwriting to printed text to bring traditional and digital tangible interactions with notes even closer.

Overall, with given improvement perspectives, the project has a potential to become a useful working tool enriching the collaboration process.