

# INTERPLAYABLE SURFACE

AN EXPLORATION ON AUGMENTED GUI THAT CO-EXISTS WITH PHYSICAL ENVIRONMENTS

HOON YOON

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**This thesis is dedicated to my parents**

**I N T E R  
P L A Y A B L E  
S U R F A C E**

**AN EXPLORATION ON AUGMENTED GUI THAT CO-EXISTS  
WITH PHYSICAL ENVIRONMENTS**

**HOON YOON**

**Interplayable**

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Above of all, I would really like to thank my parents who gave me such a wonderful opportunity to gather with international people having creative thoughts. Despite some obstacles in front of our families, they were trying to listen to my dream, and decided to financially support me even though there could be some economic burden in near future. Due to that sacrifice and commitment, I have come to meet lot of friends, and had opportunities to share my thoughts with creative people I could not anticipate before.

Thank you Mom, Dad, and especially my brother Jihoon, who also sincerely supports my success from behind.

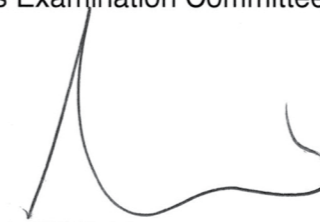
## Interplayable Surface: An Exploration on Augmented GUI that Coexists with Physical Environments

A thesis presented in partial fulfillment of the requirements for the degree Master of Industrial Design in Industrial Design in the Department of Industrial Design of the Rhode Island School of Design, Providence, Rhode Island

by

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2016

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# Interplayable Surface

An exploration on Augmented GUI that coexists with  
physical environments

**Hoon Yoon**

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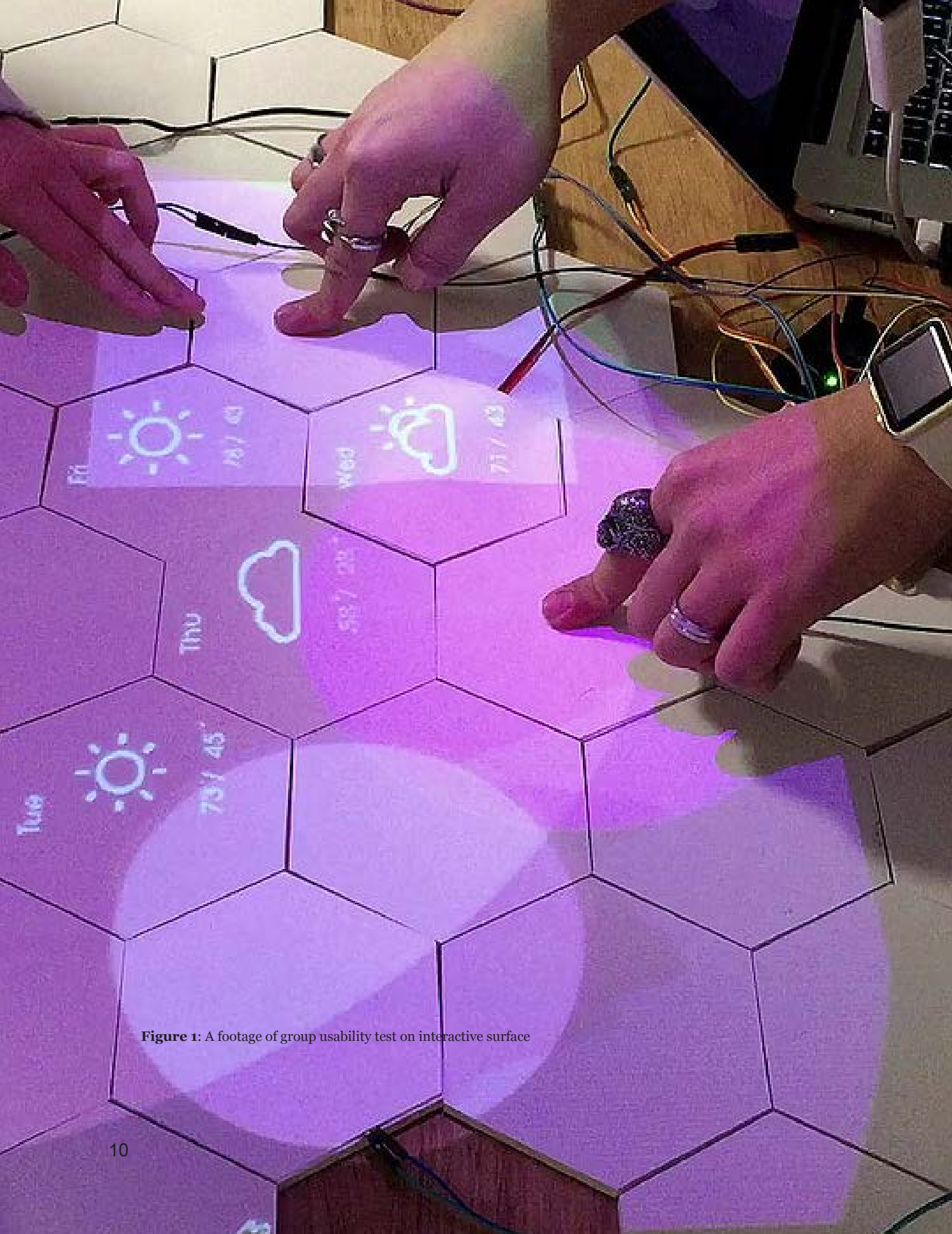


Figure 1: A footage of group usability test on interactive surface

## Abstract

The main goal of this experiment-driven thesis is to envision and design an interactive GUI<sup>1</sup>(graphic user interface) that coexists with physical surfaces. Based on an understanding of user behavioral patterns for getting access to information in these types of situations, experimentations and prototypes are implemented and tested with participants. In particular, to observe the user behavioral pattern for augmented GUI within certain environments and circumstances, this thesis presents several types of participatory experimentations with physical GUIs. The experiment participants were encouraged to participate in re-creates and reorganizes physical GUI, relating to their own situational specificity or informational tendencies they have.

Based on extracted insights from research and experiments, in the last phase, I propose two thesis models about how interactive GUI applies to a physical environment: **simulation mock-ups for user scenarios of augmented GUI** and **interactive GUI surface combined with projection mapping**. Related to people's behavioral patterns on augmented GUI, the thesis models will show several types of information structures and interactions. Also, in framing the overall data structure and wireframe for the thesis product model, informative affordance corresponding with users' situational specificity<sup>2</sup> is considered as a crucial direction point, actualized on an artifact in a perceptible way. Through experimentally prototyping a thesis model, consequently, I would like to expand the speculative usability interactive GUI will feature in the near future.

## Keywords

Interactive Design, HCI, GUI/UX, Augmented Reality, Affordance, Projection Mapping

1. Basically, GUI(Graphic User Interface) is the term commonly used for representing the interface of smartphone, computer, web-design. But in this thesis, GUI is utilized into an expanded meaning that represents augmented interface projecting on a physical surface.

See theoretical definition, usage about GUI:

[https://en.wikipedia.org/wiki/Graphical\\_user\\_interface](https://en.wikipedia.org/wiki/Graphical_user_interface)

2. Similar to the term Site Specificity, **Situational Specificity** is the synthetic term I made for representing user's certain situation at accessing information: for example, when somebody is in need of quickly verifying the bus schedule right before missing the bus, I would like to interpret that as a moment of accessing information under a certain situational specificity.

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## Introduction

The enormous increase in interactive digital tools in recent decades has changed the way we communicate. As time passes, more and more people are communicating via digital devices. This has meant an explosion in people who are able to simultaneously deal with multitasking in terms of managing their time, sharing thoughts with others, and reaching out to people across the globe. The UI experience in a smart device is highly immersive, and thanks to graphic motions and effects, users have come to perceive them as living objects, not just programmed things. Meanwhile, thanks to the emergence of cloud systems, data accessibility has been enhancing at all times, for all spaces and platforms, regardless of the format of a device.

In experiencing diversified technologies, judging its usability from the conventional viewpoint has come to be pointless these days. While early computers had more complex interfaces, current ones have become more simplified, clarified for relatively small-sized devices such as smartphones. Optimized for user's informative propensity, its usability is becoming more interactive and irreplaceable in our lives. People get access to social applications and communicate and share what they experience with others through applications designed with intuitive UX platform. Also, as a smart tool, applications actively reads users' intentions or tendencies while searching information and suggest suitable information for them.<sup>3</sup> Also, in defining the usability that contemporary technology contains, its technological boundary that intersected between several functionalities has become ambiguous due to the emergence of collaborative experiences. Unlike a previous usability of accessing applications aiming on functionality or productivity, an experience via interactive interface is being more immersive, by integrating with actual daily lives.

User experiences in digital mediums are highly interactive and collaborative with external environments. For instance, Apple Inc.'s commercials show lots of futuristic possibilities for products to coexist with external human environments. From Apple's iPad commercial in 2014,<sup>4</sup> highly interactive technologies are interplaying with diverse users and harmonizing with situational specificity beyond their functionalities. Likewise, various design projects based on speculative lifestyles are currently being incubated. In designing a product's UX (user experience) strategy, it is becoming a common thing that designers and developers are sharing their ideas of how

3. For example, "Pinterest" provides an user-oriented service. Users who accesses its website or application are able to experience the customized clusters of relevant images based on their keywords. In particular, automatically selected group of images can be shared with and be freely manipulated by friends via SNS account like Facebook, Twitter.

<https://www.pinterest.com>



4. See the Apple's Ipad commercial:  
<https://www.youtube.com/watch?v=1mYCIKTX0ug>

the futuristic user scenario is going to happen in actual environments. By envisioning our living spaces as a new platform where digital interaction is going to be applied, IT commercials and speculative studies are illustrating a scene in which digital interaction coexists with the physical environment,<sup>5</sup> communicating and assisting us in every single time.

## Integrating augmented reality with actual environment

From this viewpoint, the emergence of augmented reality shows the possibility that information combined with human-centered technology could be applied in an actual environment and communicate with users as an interactive being. For example, home automation embedded with IOT<sup>6</sup> technology shows a user scenario in which users access the application that enables them to remotely control the devices in residence, verifies the information regarding the status of residence or device itself via smartphone, and easily responds to it by tapping the UI configuration button of application. In perceiving information combined with an external environment, as mentioned, its interactivity with the actual environment is continuously being reinforced. Argodesign's concept video, "Smart Dumb Things<sup>7</sup>," speculatively illustrates the futuristic usability of adapting augmented reality into actual life. Like ordinary activities in friendly environments, they perceived augmented GUI as it originally was. They were playing games or doing work transformed into augmented GUIs. Through this prototyping, they experimentally demonstrate how the augmented information will permeate into our daily life and environment in the near future.

In experimentally envisioning the possibility of integration between AR and actual life, Julia Tsao's thesis work, "Curious Displays<sup>8</sup>," tells a few clues on how to integrate augmented information with the physical environment by utilizing interactive mediums. In her thesis work, she speculatively designed the relationship in a particular way that the augmented visualization exists within a space and reacts to a physical environment while moving over it. Frameless GUIs float over a carpet in the form of numerous fluid particles, and their particles collectively create several shapes of TV screens reactive to physical environment. In terms of exploring the interactive flexibility on constructing informative structure, informative fluidity inspired me in how augmented GUI interplays with actual environment.

5. See Jack Schulez's Article, Media Surfaces: Incidental Media(2010). In his article, he portraits how augmented reality interacts with user and permeates into real life. His article's posting date is 6 years ago, but it would be surprised to see that some of technologies have become now realized or commercialized.

<http://berglondon.com/blog/2010/11/03/media-surfaces-incident-media/>

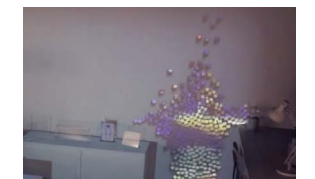
6. See the theoretical definition of IOT :

[https://en.wikipedia.org/wiki/Internet\\_of\\_Things](https://en.wikipedia.org/wiki/Internet_of_Things)



7. See "Smart dumb things", which portraits the futuristic scene of digital interaction permeates the real life.

<https://www.youtube.com/watch?v=87zlv7SL-5Q>



8. It is an experimental project that abstractly shows that interaction assimilates with the environment of private space.

Julia Tsao, Curious Displays, Graduate Thesis Project, Fall 2009, Media Design Program, Art Center College of Design:

<https://vimeo.com/9486977>



## Thesis Roadmap

Fundamentally, the ultimate direction point of the thesis aims to speculatively design the augmented environment integrating with interactive, GUI-embedded artifacts via projection mapping. Based on experimenting the conditions and situations that digitize visual interactions coexisting with daily life, the thesis will experimentally propose the usability for how users interact with augmented information projected on an actual surface within a situational specificity.

To define the user for this thesis project,

- The prospective user group for research and experiment in this thesis is partially limited to those skilled in, or accustomed to using, digital smart devices like smartphones, laptops, tablet PCs, etc.
- In terms of user scenario, most of the thesis experimentations and final outcomes are basically subject to the circumstance of hypothetically interacting with augmented GUIs within a certain situational specificity.

The flow chart below is about the overall sequential procedure for thesis activity as main part of whole thesis.

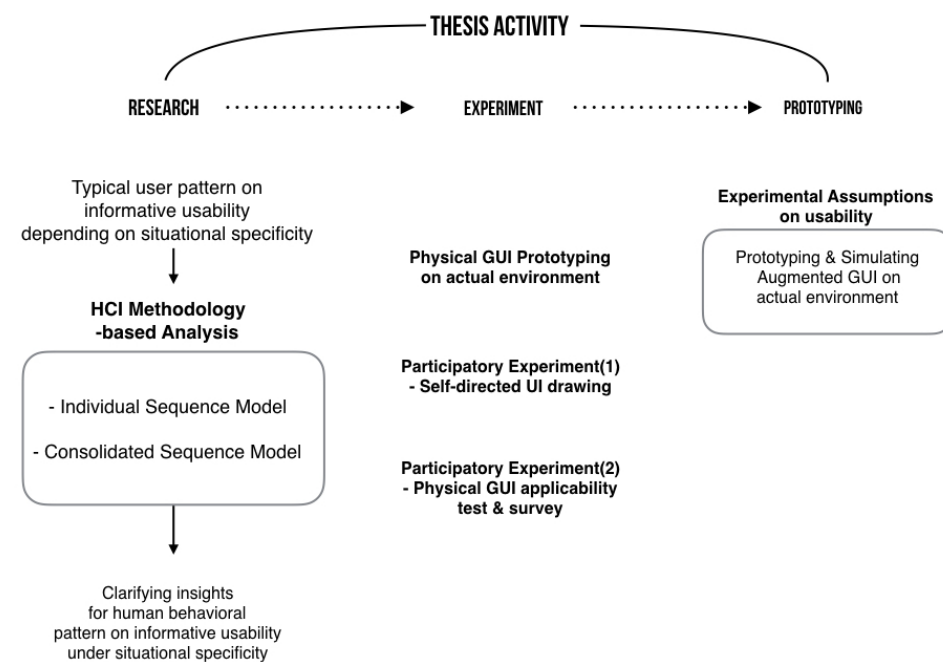


Figure 2: Sequential flow chart for planning thesis activity.

In research phase, in order to analyze user's usability pattern on information under situational specificity,

- HCI framework will be utilized as a main methodology in Chapter 1.
- Analyzing the cases of a usability pattern into the form of a consequential algorithm and individual and consolidated sequence models derived from HCI methodology will be utilized.

- Based on data, insights will be clarified, which is relevant to constructing informative structure for designing GUI at the final phase of the thesis.

In the experimental phase, in order to research users' information propensity under situational specificity, participatory experimentations will be conducted with various types of participants to clarify user insights of informative tendency at a certain situation.

In the prototyping phase:

- Physical GUI stickers will be used in **Chapter 2** in order to simulate augmented reality in actual environments.
- In **Chapter 3**, participants will use a sticker pad to draw their own GUIs and attach what they draw on small-scaled LEGO interior sets representing average living spaces.
- In **Chapter 4**, participants will use physical GUI stickers, attaching them to a certain spot in their private spaces like residences.

In the prototyping phase:

- Overall, projecting mapping will be utilized as a main tool for actualizing interactive GUI in a physical environment

To conduct visual projection mapping for experimentation, technical tools are suggested as follows:

- The visual art programming software called Processing will be mainly utilized for actualizing digital interaction and visualization as a way of programming code for it.
- Adobe Photoshop and Adobe After Effects will be utilized in order to prototype the scenario that the augmented GUI interplays with physical environment.
- Based on the codings program from Processing, visual interaction will be projected on the surface via projector.

As the thesis outcomes, in **Chapter 6,7** I finally proposes two thesis models:

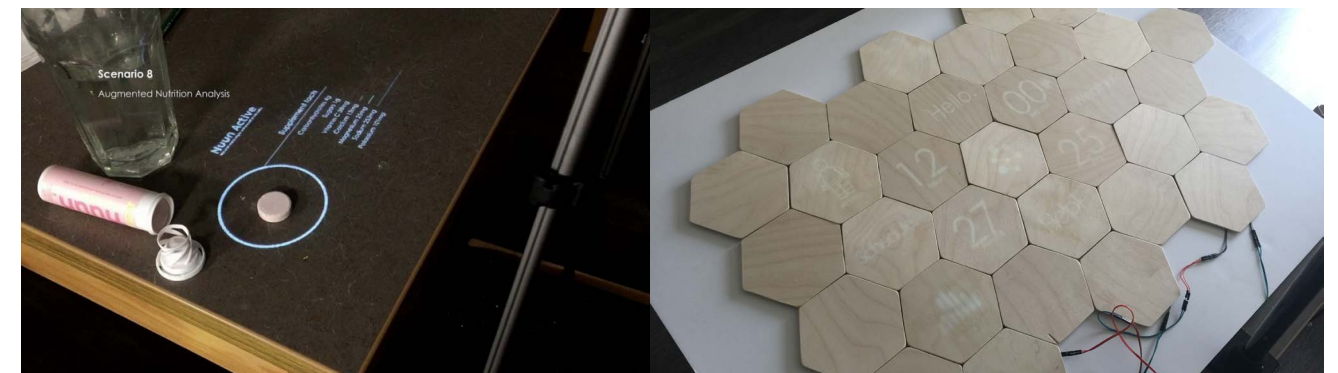


Figure 3: (Left) Sequential simulation mock-ups for User-scenario of augmented GUI (**Chapter 6**)

Figure 4: (Right) Interactive surface that combines with reactive GUI (**Chapter 7**)

# Chapter 1.

## Understanding user behavioral pattern under situational specificity

### Analyzing user's inherent behavioral pattern with HCI methodology

When or where do you usually get information? What kind of information do you usually get access to under the certain circumstance? How do you get information under time pressure? As a theoretical background for actualizing thesis model, understanding the user pattern under situational specificity was demanded to initially map out the overall UX structure of visual interface.

This research aims to methodically analyze people's informative propensity under certain situational specificity. In order to clarify the behavioral pattern, the HCI<sup>9</sup> framework (Individual Sequence Model and Consolidated Sequence Model) will be utilized in clarifying the sequential algorithm of a user's informative tendency.

\* The frames of sequence models showing from the following sections are theoretically cited from the framework introduced in "Sequence Model Analysis," "Kim, Jin Woo(2012), Human Computer Interaction 개론 pp 254, 255." On the basis of HCI frames, user behavioral patterns were sequentially reorganized and clarified.

9. See the theoretical introduction of HCI(Human Computer Interaction):

<https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/human-computer-interaction-brief-intro>

\* Example of *Sequence Model* irrelevant to HCI:

<https://ccit333.wikispaces.com/Sequence+Model>

### Case 1: User information accessibility under time constraints

In general, people have similar tendencies for retrieving information. Depending on certain situations they have, their behavioral patterns on searching and manipulating information is a bit similar from the experiential viewpoint. We tend to immediately get proper information when the situation requires it, like quickly searching the address of where you should visit, or certain information that helps you to choose the right direction.

For example, when cooking without having proper knowledge or a recipe or getting stuck in the middle of the cooking process, people try to find a way to deal with it. Besides taking a look at a cooking book, they utilize their smartphones. They get access to blogs or websites containing cooking knowhow and put a smartphone displaying a page of the recipe beside the gas range while cooking. Particularly, in the case of getting information within a very short moment, like quickly searching the information about the proper amount of salt when it is time for seasoning, the rapid process of accessing information is demanded at that moment.

Related to those examples above, in order to analyze how people access information under situational specificity, I analyzed several types of user behavioral patterns in the HCI Sequence Model.

The first case in the next page is about quickly accessing a bus schedule right during heading to the bus station.

\*Based on various types of activities of utilizing application via smartphone under situational specificity, I constructed several versions of user's behavioral sequence model in order to methodically analyze the algorithm of workflow that each events inherently contains. To introduce, in **Figures 5, 7, and 9**, user behavioral patterns for getting access to applications via smartphones under certain time conditions will be analyzed in a frame of HCI's Individual Sequence Model. And then, in **Figures 6, 8, and 10**, data will be reorganized and clarified into an activity definition, intention, sequence, and insight keyword in a frame of HCI's Consolidated Sequence Model.

## INDIVIDUAL SEQUENCE MODEL 1

### Objective:

Urgently verifying the bus station via smartphone before the bus leaves soon

Intention: To quickly check out the location under the time constraint

Precipitating cause: User do not know where to head for taking a bus because he has not been to that area.

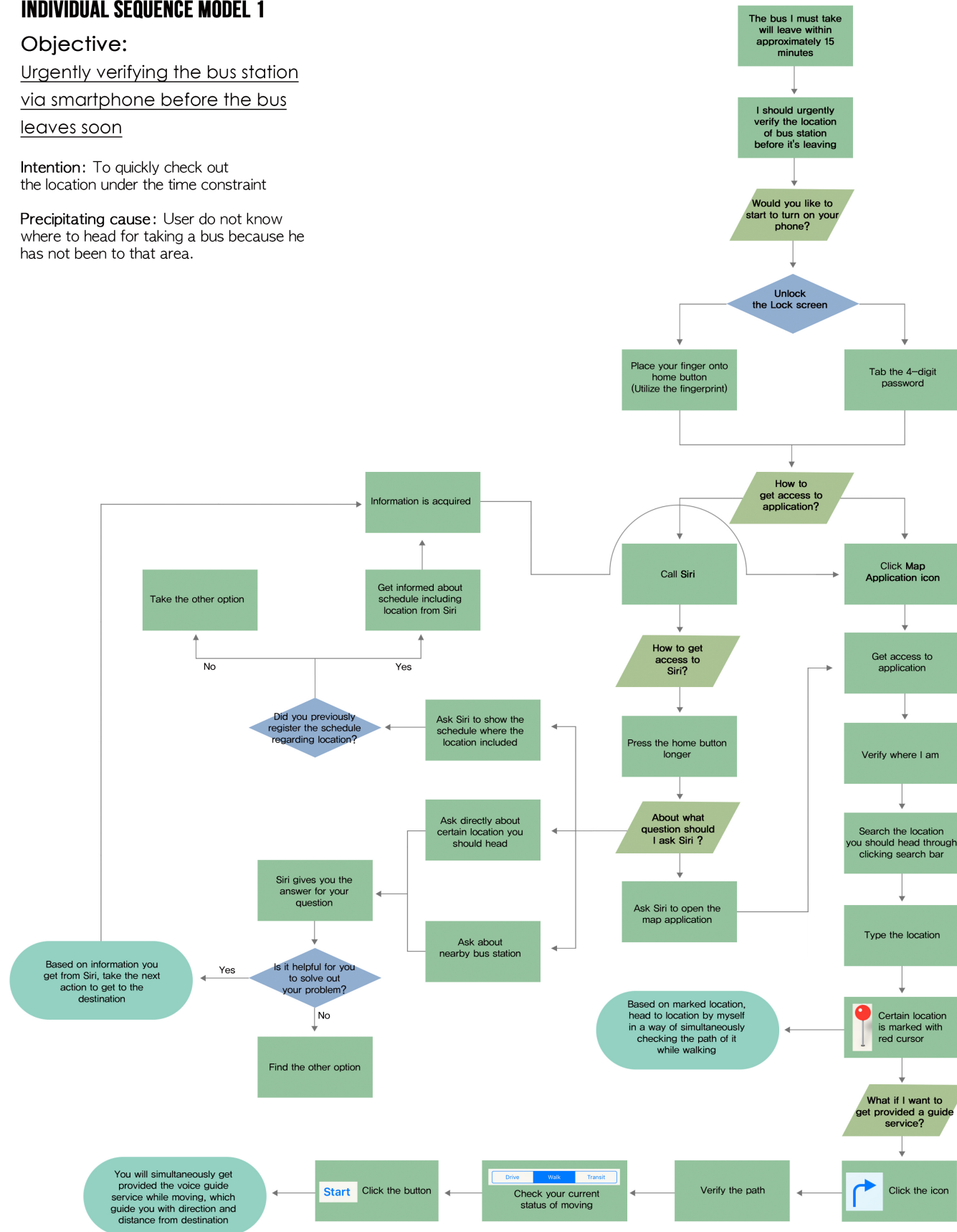


Figure 5: Individual Sequence Model for a situation of getting access to a map application under time constraint.

After framing the algorithm of user-behavioral sequence, a chart below shows the Consolidated Sequence Model in which the behavioral sequential patterns are reorganized into certain criteria.

Activity Definition	Intention	Sequence	Insight Keyword
Situational recognition	Recognizing the need of urgently verifying the certain location under time constraint	<ul style="list-style-type: none"> <li>Perceive the urgent situation</li> <li>Perceive the rest of time</li> <li>Grab the smartphone</li> </ul>	
Access	To search the information, get access to OS(Operating System) of smartphone	<b>Turn on the phone</b> <ul style="list-style-type: none"> <li>Click the home button</li> <li>To unlock the screen lock, <ul style="list-style-type: none"> <li>Tab 4-digit password</li> <li>place finger you previously registered on home button</li> </ul> </li> </ul>	<b>Alternative accessibility as hotkey for urgent situation is demanded for shortening the time</b>
Approach	To achieve a goal, get access to application which provides the scheduler service	<b>To get access to application,</b> <ul style="list-style-type: none"> <li>Click the application icon</li> <li>Get access to scheduler app which might include some information about certain location</li> </ul>	
Communication	As a different approach, ask Siri(AI) about where to head, or nearest bus station, in terms of fastly acquiring diverse clues	<b>Click the home button longer to get access to Siri</b> <ul style="list-style-type: none"> <li>Ask where I should head</li> <li>Ask shortcut to reach the location</li> <li>Ask nearest bus station</li> </ul>	<b>Accuracy for answering questions about certain information should be enhanced for Siri</b>
Search	To verify the path/shortest distance to get to the location	<b>To verify the destination,</b> <ul style="list-style-type: none"> <li>First, verify where I am</li> <li>Search the location through search bar</li> <li>After verified it by red cursor, start to go towards it</li> </ul> <b>If you want take a guide service,</b> <ul style="list-style-type: none"> <li>follow the introduced procedure <ul style="list-style-type: none"> <li>Click the icon</li> </ul> </li> <li>Check your status of moving</li> <li>Click the start button</li> </ul>	<b>In addition to voice guiding service, intuitive approach for providing information to users at certain circumstance is needed</b>

Figure 6: Consolidated Sequence Model for a situation of getting access to a map application under time constraint.

Under the situational specificity in which simultaneous events are happening at one time, getting provided clarified, clear, informative composition or a solution undistruptive to subsequent activity was significantly important. Likewise, several situations, like verifying the bus number via smartphone right on the verge of getting on a bus or checking the time for entering a facility on the verge of closing time means similar direction points: In terms of informative affordance, purposefulness of informative attributes should directly correspond with the user's situational specificity.

## **Case 2: User information accessibility without time pressure**

In contrast to the tendency of trying to searching information under limited situational specificity, people tend to show different behavioral pattern when they are not in a situation of immediately accessing information under time pressure. In other words, it means that they could afford to spend some amounts of time on consuming information they want regardless of situational specificity that psychologically limits the opportunity of being aware of information.

Considering that situation, the contents and medium they utilize can be diverse: when they use digital devices(e.g. smartphone, or tablet pc, laptop), it was frequently observed that they spend their time on mostly watching news, blog, youtube, or communicating with somebody via SNS(e.g. Facebook, twitter, Instagram). Most of information structures these kinds of applications contain normally consist of densed UI interfaces, combining with graphical interactions. In terms of providing various informations to users, applications the vast majority of users access like facebook, youtube pursue different kinds of UX strategies, which is distinctive to the other applications aiming for a certain purposefulness.

So, in that sense, considering the fact that the user in an urgent situation could not be fully aware of sufficient amount of information, those not in time pressure can deal with multitasking via devices in terms of productive usability: they simultaneously read the news feed with listening to music, or even watching the video-clip on youtube.

A HCI Model in next page is about the situation of getting access to schedule app without time pressure.

## INDIVIDUAL SEQUENCE MODEL 2

### Objective:

Checking today's schedule via  
iphone's Calendar App

Intention: To verify the today's  
schedule that I don't recall quite well

Precipitating cause: User has a  
breaktime during class

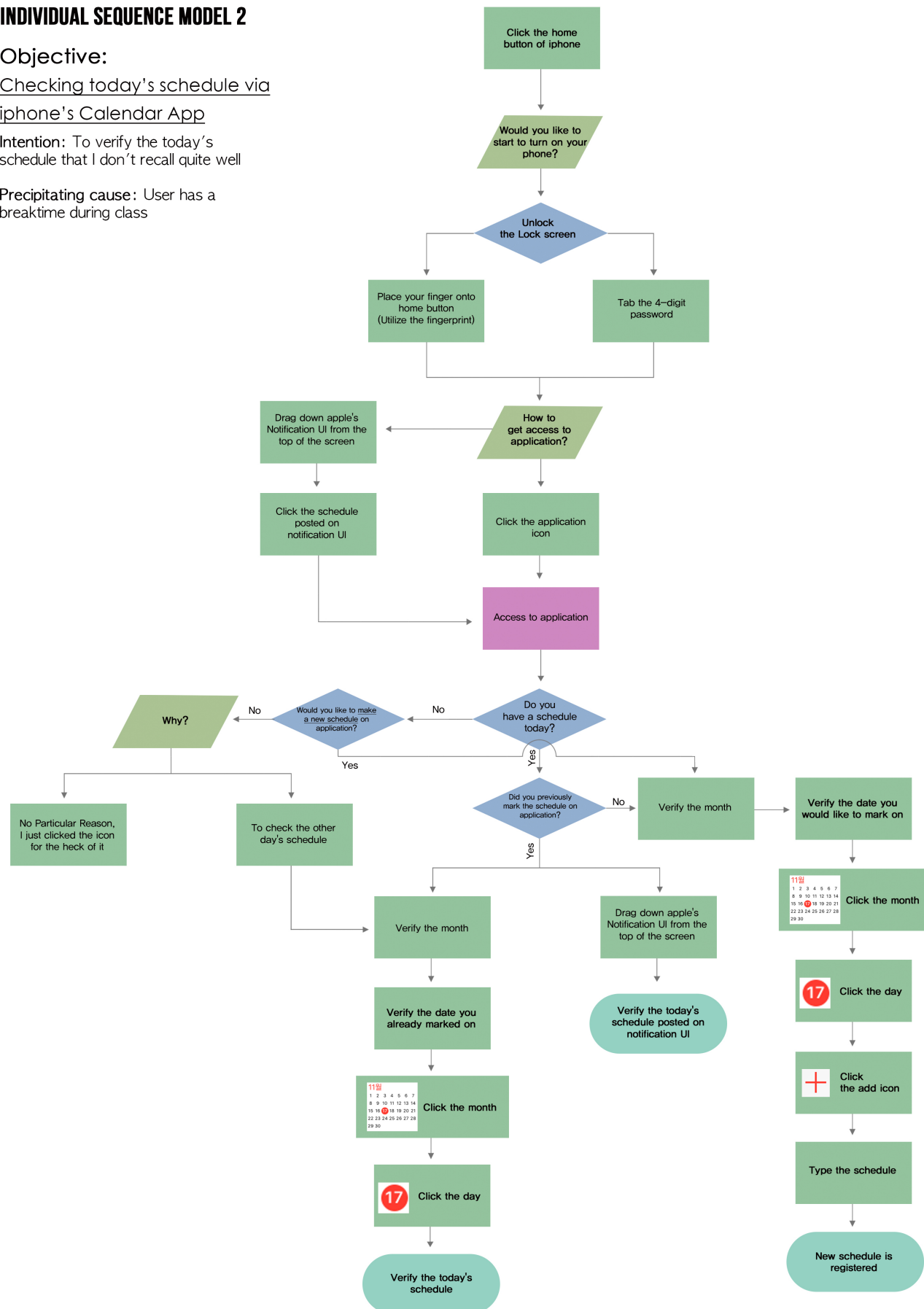


Figure 7: Individual Sequence Model for a situation of getting access to iPhone's calendar app without time constraint

Same as **Case 1** analysis, I reorganized the factors and extracted insights by using consolidated sequence model.

Activity Definition	Intention	Sequence	Insight Keyword
Situational recognition	Recognizing the need of verifying the schedule	– Grab the smartphone	
Access	To achieve a goal of searching the schedule, get access to OS(operation System) of smartphone	Turn on the phone – Click the home button – Unlock the screen lock, – Tab 4-digit password – place finger you previously registered on home button	
Approach	To achieve a goal, get access to application which provides the scheduler service	To get access to application, – Click the application icon – Drag down apple's notification UI from the top of screen – And then click the schedule posted on notification UI	
Search	Verify the schedule I previously registered	To verify the schedule, – Firstly, check on the month and date you registered – Click the month – Click the day – Verify the schedule showing up in along with calendar  To verify the schedule without accessing to application, – Drag down Notification UI from the top of screen – In case you previously registered the schedule on the day, it will be posted up on notification UI.	Alternative accessibility as bypass, in case of having a situation of urgently verifying a schedule
Register	Register a new schedule in case I currently do not have it on application	– Check on the month and date you would like to register beforehand – Click the month – Click the day – Click the add icon to type a new schedule – Type a new schedule – You will get notified when the scheduled time is arrived	Necessity of User Centered–UI structure to properly navigate within application

Figure 8: Consolidated Sequence Model for a situation of getting access to iPhone's calendar app without time pressure

### Case 3: User information accessibility via hotkey

Besides the situation of immediately searching for information under situational specificity, users utilize hotkeys in order to directly access what they want to acquire. In this case, the overall access sequence is relatively shorter than the usual sequence for getting access to an application, so the user can rapidly access the application within 1~2 taps. In regards to applications we can use as hotkeys, those attributes are highly prioritized and commonly usable in the user's daily life, such as a camera, light, stopwatch, timed alarm, and calculator.

#### INDIVIDUAL SEQUENCE MODEL 3

##### Objective:

Using a hotkey without getting access to OS (on basis of iPhone's hotkeys)

Intention: To shorten the time to get access to the application I want

Precipitating cause: User abruptly stumbled upon something to do (to take a picture, to calculate, etc) while walking

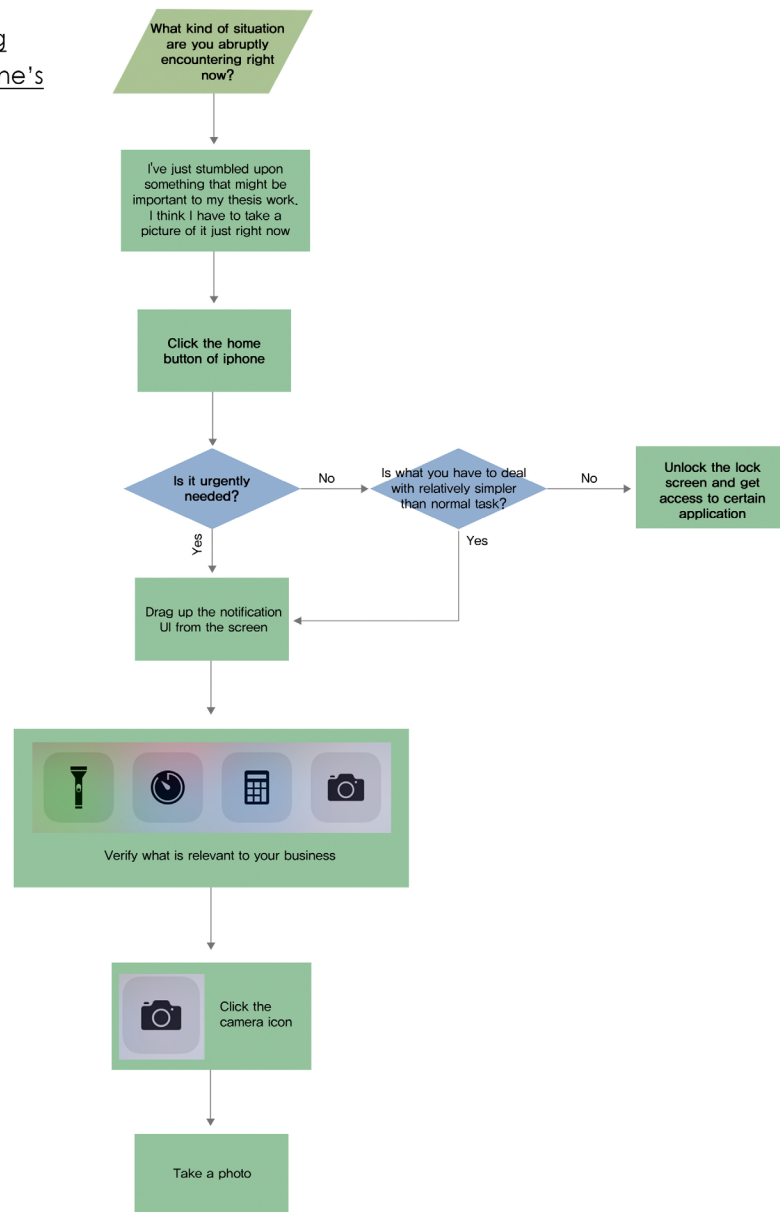


Figure 9: Individual Sequence Model for a situation of quickly getting access to camera app by utilizing a hotkey on the notification UI of iPhone

As the other cases, Consolidated Sequence Model was implemented as follows.

Activity Definition	Intention	Sequence	Insight Keyword
Situational recognition	I've just found something while walking, and I would like to take a picture of what might be influential to my thesis work	<ul style="list-style-type: none"> <li>Perceive what is relevant on your interest</li> <li>Grab the smartphone</li> </ul>	
Access	To access to application	<ul style="list-style-type: none"> <li>Turn on the phone</li> <li>Click the home button</li> </ul>	
Approach	To quickly access to application	<ul style="list-style-type: none"> <li>To get access to application,               <ul style="list-style-type: none"> <li>Drag up the notification UI from the screen</li> <li>Verify the application hotkey relevant to what you have to deal with</li> <li>Click the icon</li> <li>Quickly take a picture</li> </ul> </li> </ul>	In addition to current application hotkey, possibility for customizing the hotkey based on user's personal preference is strongly needed

Figure 10: Consolidated Sequence Model for a situation of quickly getting access to the camera app by utilizing a hotkey on the notification UI of iPhone

### Reviewing sequence behavioral model

Based on insights extracted from consolidated sequence models, key factors for designing informative structures linking with situational specificities are suggested as follows.

#### Importance of information affordance under situation variable

In selectively collecting information under situational specificity, a simplified, clarified information structure corresponding with a certain direction is crucial for

users to navigate through adequate application. As presented from the usability factor of an HCI framework, user accessibility on accessing and perceiving information is considerably influenced by informative structures, especially under certain situation variables. In particular, usability in the situation of quickly searching information can be affected, fluctuated by the informative affordance the application's GUI contains. For instance, depending on a certain level or degree of UX sequence algorithm that application intends, user accessibility in different situations can be vary, and users' ability to recognize information cannot be guaranteed. In similar context, *Donald Norman* explained in a way that an affordance object contains influencers in how people react to it in terms of relational environment(Norman, 2013)<sup>10</sup>. From this point, in designing practical usability associated with situational specificity, entailing a UX sequential algorithm aimed for several types of user scenarios has become important to designing proper information affordance in this thesis.

### Time-shortening accessibility

Noticeably, in a generic viewpoint, sequence models show some point that time-shortening accessibility for getting access to application is utilized as alternative in regardless of situational specificity.

Even in the situation of accessibility to applications user frequently used in non-time constraint conditions, as **Figure 2** shows, the other optional way to approach applications (e.g. drag down the notification UI from the top of the home screen to verify a schedule or ask Siri about the schedule) became relatively more reasonable in terms of shortening the time to access them, compared to a conventional way of access, like entering through the lock screen at the beginning.

Besides, what is a characteristic of a user-friendly UX system that allows users to easily get access to their most commonly used applications within a very short sequence procedure? For using a daily application the vast majority of people utilize in life, such as a watch, calculator, or lighting application, just by dragging up the notification UI from the top of iPhone's home screen and clicking the icon, users could quickly approach the application and use it within 2 steps without accessing it through the lock screen.

### Existence of alternative

As introduced at **Figure 6**, providing several alternatives as bypasses to reach information can allow users flexibly to choose the other optional way of getting access to it, depending on a user's situational specificity.

### Flexibility of informational composition depending on a situational specificity

Related to the point of information affordance mentioned from above, in properly navigating certain information users want to find, either an informational amount or structure in an application is crucial for users to choose the selective information, especially that which is in combination with situational specificity: That is, depending on the degree of informational composition that an application contains within situational specificity, such as being under a time constraint, users' accessibility and ability to perceive getting information could be irregular and consequently disruptive to approaching proper information. As shown in **Case 1**, in case of a situation of urgently finding out the certain information within a limited time, an un-clarified information structure rather hinders the user's concentration in acquiring suitable information to solve out the external problem. To effectively reach suitable information within a certain circumstance, flexibility of informational structure or composition in application is required.



**Figure 11:** Preparation for conducting experiment. The GUIs I designed were mostly about applications considered to widely used in daily life: Weatherforecast, Music Player, Lock Screen, Menu, Search Bar, etc.

## Chapter 2. Physical GUI prototyping on actual environment

### Speculating augmented GUI's coexistence with physical environment

In designing the augmented GUI structure, speculatively examining its usability in the actual environment was preemptively considered in terms of informative suitability relevant to the external environment.

In this chapter, in order to explore how the augmented GUI interacts with an ambient environment, I made various types of GUI stickers and speculatively verified how the GUI coexists with physical surroundings through it. In simulating situations relevant to GUI, navigating music applications while or on the verge of taking a shower, verifying today's weather forecast, and checking the state of food in a refrigerator were considered.





Figure 12: Weatherforecast GUI on the window glass

## Attaching physical GUIs on the surface

Recently proposed as a speculative technology in the industrial design field, displayed GUI on the transparent surface is to be considered as a pivotal platform in materializing interactive interface. For instance, in CES 2012, Samsung presented “Samsung Smart Window<sup>11</sup>,” which was a transparent LCD window responsive to user touch. Distinctive to typical interactive GUIs displayed on the surface, what was intriguing in terms of usability was that its GUI was highly immersive due to the factor that GUI was interacting with the physical environment in an augmented way.



11. See Samsung Smart Window:

<http://www.chipchick.com/2012/01/samsung-smart-window.html>

Similar to that, I also experimentally attached a weather forecast GUI sticker on the glass of a window in order to estimate how the augmented GUI environmentally adapts to external surroundings. Below is the footage of experimentation in a residence where I currently live.



Figure 13: Music blog on the window glass



**Figure 14:** I thought of several scenarios of applying different kinds of GUIs on the surface of refrigerator. A picture on the left is about the situation of on the verge of clicking an icon of favorite song when opening a refrigerator. The other scenario I come up with is the situation of unlocking the door to get a food or soda.



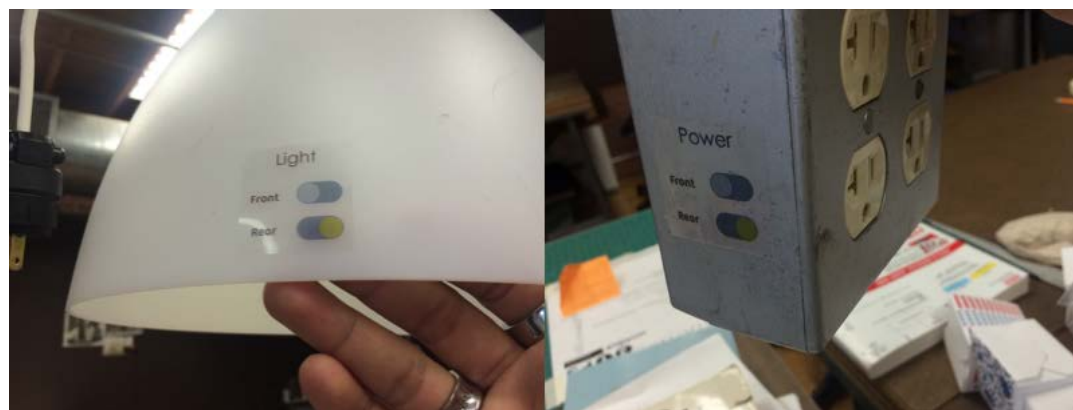
**Figure 15:** Transparent lock screen on door handles



**Figure 16:** Weatherforecast GUI on the bathroom glass and near the lighting switch. To explore specifically, I chose several surfaces which are suitable for attaching it as a venue for getting provided weather information: The left picture on the top is when I attached a sticker right beside a lighting switch on the wall of the living room. The rest of the pictures show that I attached it to the mirror in the bathroom. To explain this situation, I thought about general behavioral patterns that most people show in a process of perceiving daily information or interplaying with applications through smart devices (e.g., weather information, schedule, playing music they like, etc.) in morning.



**Figure 17:** Search bar GUI sticker on the column near the exit door of MID studio. I assumed the situation that user improvisationally search a keyword on the verge of leaving the building.



**Figure 18:** Virtual control panels for physical devices.

## Experimentation Insights

### Contextual coexistence with the environment

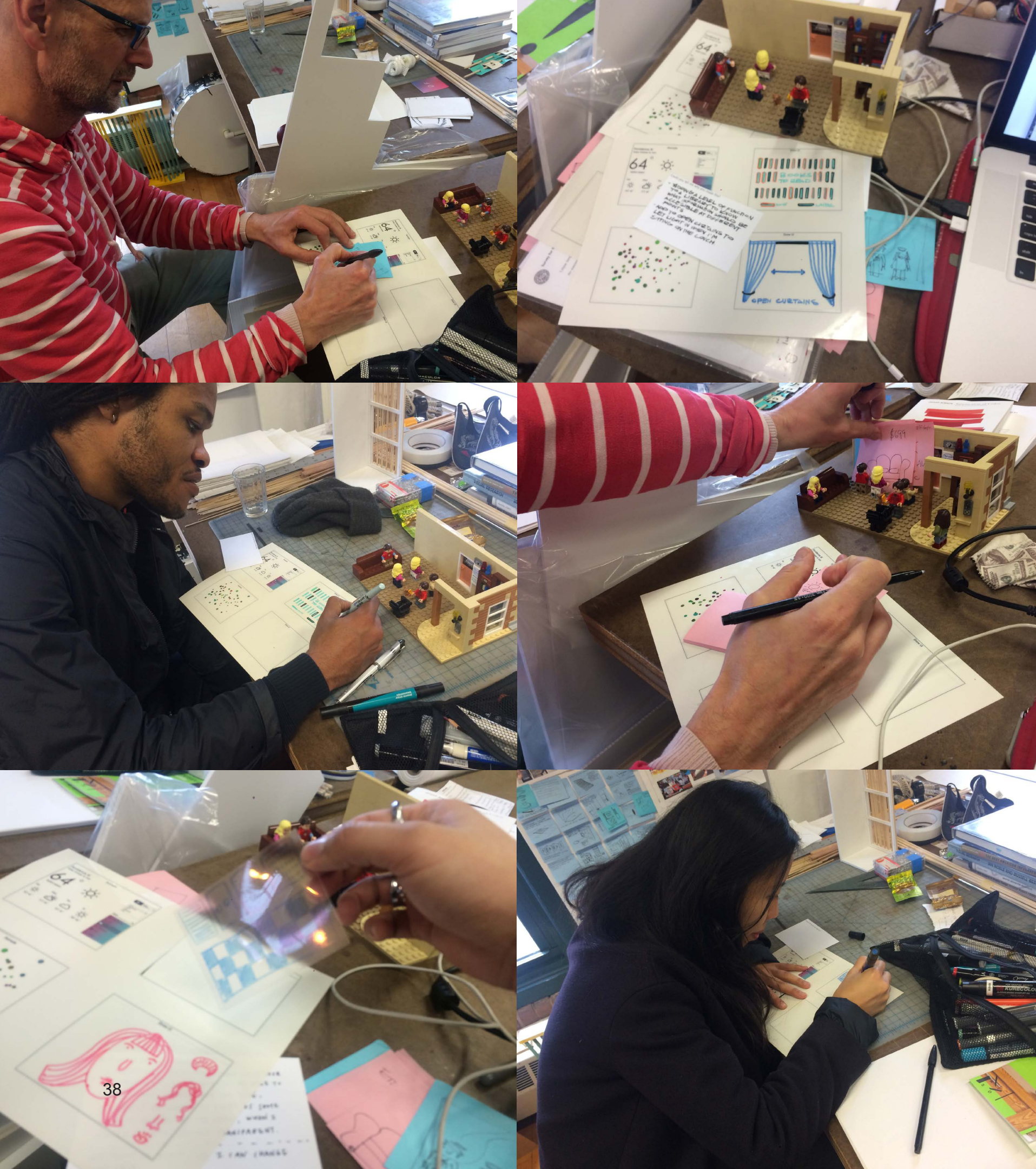
In speculatively applying augmented GUI to the physical environment by utilizing stickers, this chapter's experimentation has indicated a possibility on how augmented information, notifications, and functions interact with physical ambient objects as part of them. As a digitized function and informational expansion of external environment's objects, some of the exercises from the experimentation were showing contextual coexistence with environmental contexts, particularly for **Figure 16's** GUI stickers attached to the bathroom mirror. What I could see was that the usability the GUI intends was contextually collaborating with the bathroom's situational specificity users used to have (For example, as mentioned from **Figure 16's** caption, the user simultaneously verifies and searches simple information like the weather forecast and news displaying on the bathroom mirror while brushing his teeth).

### Imitating a physical product's original functionality

In designing an augmented GUI that imitates the functional element the physical product originally contains (e.g., **Figure 15's** lock screen UI or **Figure 18's** switch UI), the experiment showed a possibility that GUI could functionally be utilized as a virtual component, not just an informative medium.

### Adjusting the quantity of information for augmented GUI

The experimentation also indicated that information recognition and accessibility on augmented GUI could be changed depending on certain circumstances where the GUI is applied. For example, as in **Figures 12, 13, and 16's** situations, it does not matter for users to face some amount of information when he gets proper time to take a look at it. On the other hand, in the case of **Figure 17's** simple search bar with GUI near the door, simplified, clarified information is needed for people to quickly access right before going out. So, in terms of actual information accessibility, considering user's situational specificity within a certain space is required in designing informative quantity and volume.



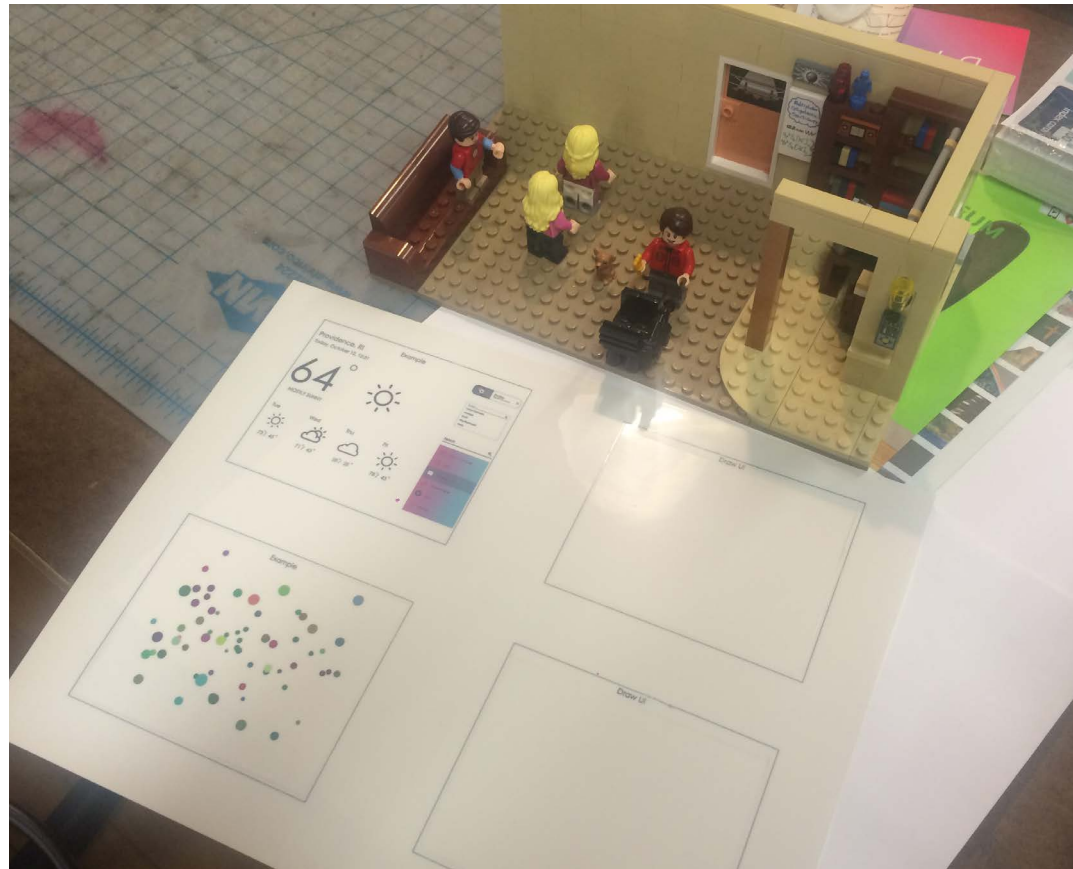
## Chapter 3. Participatory experiment (1): Self-directed UI drawing

### Exploring the potential user's mind

As a means for actualizing practical usability relating to user environment, communicating with actual or expectable users, and inherently getting to know about their preference patterns for approaching GUI in daily life are significantly important to the composition of the overall structure and contents within. From this phase, I started to think about the possibility that I encourage nearby people to engage in an experiment as participants and give them time to manipulate the graphical environment into their own ways, just as a playful activity. What was the most successful, insightful outcomes during this participatory experiment was that I could experience their diverse, unexpected, even irrational approaches in generating ideas for designing their own GUIs on small-scale LEGO structures supposed to be their living rooms in the experiment. During participation, it became clear that depending on certain types of environmental situations or scenarios participants thought of, what they were creating contextually contained different meanings. Ranging from the idea of necessity of what to deal with to the idea for playful activity, each participant's concepts were closely based on their own actual needs for living.

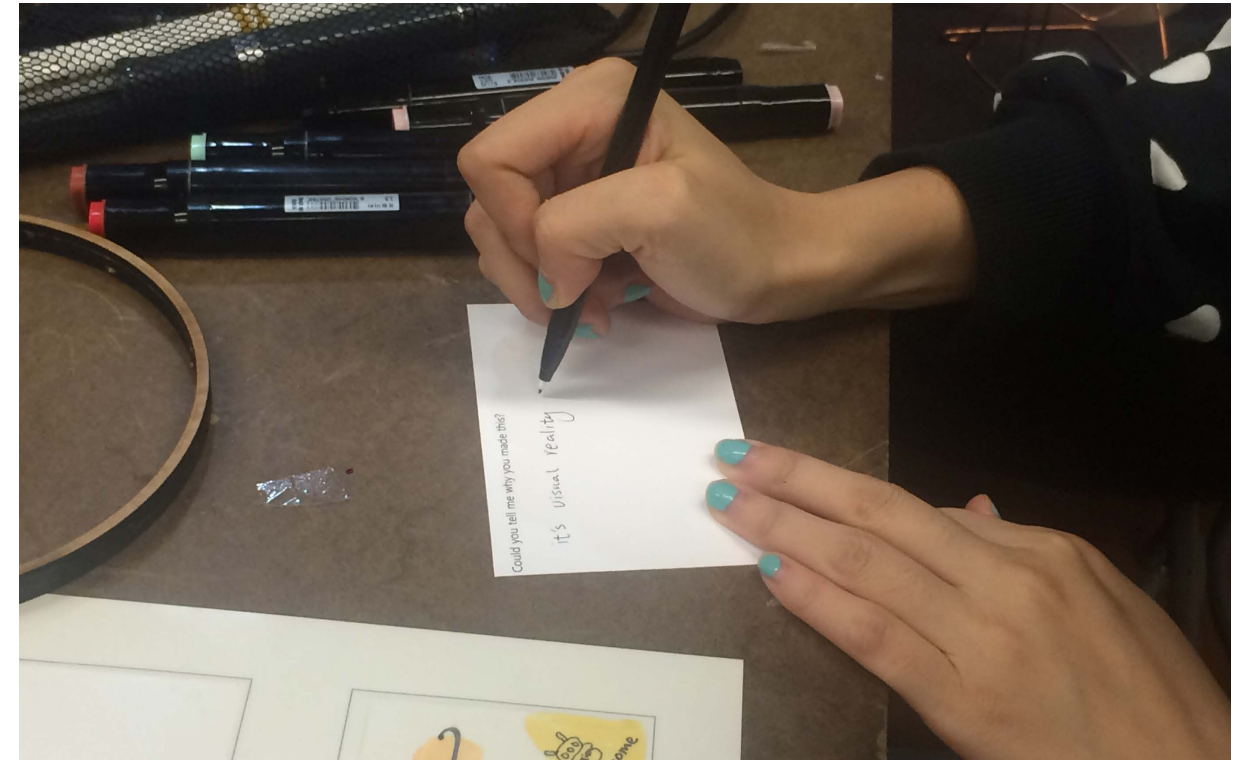
**Figure 19:** Footages of conducting participatory experiment with my classmates and faculties of MID program, RISD.

## Experiment procedure

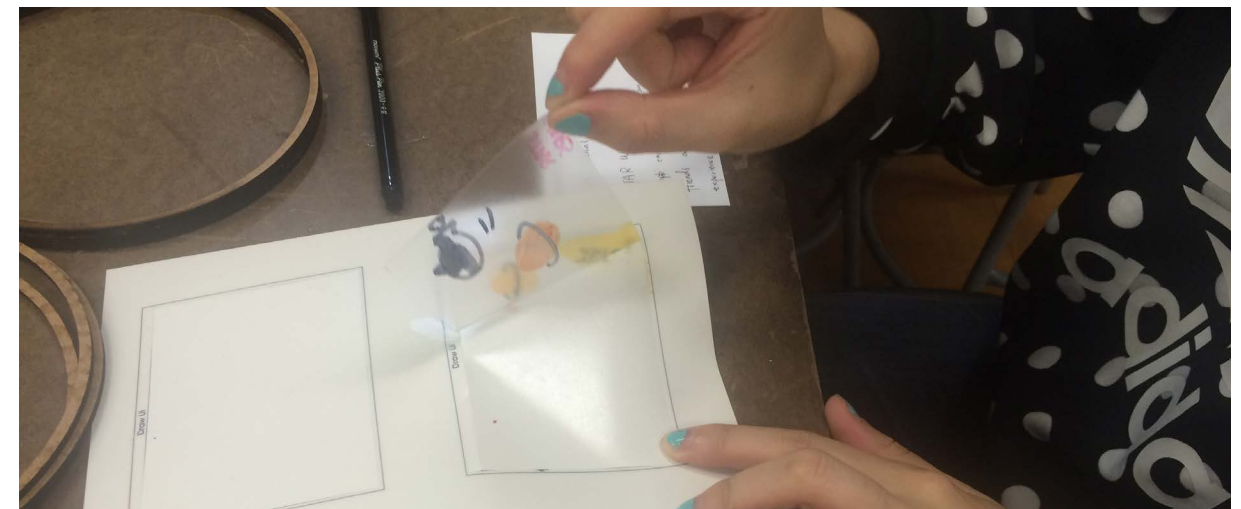


**Figure 20:** Preparation for experiment. Participants draw their idea on an adhesive drawing pad and attach it to the small scaled-simulation structure made by LEGO.

To introduce the overall procedure, the experiment consists of three parts: (1) detachable transparent sketchpad for drawing GUI; (2) small-scale interior made by using LEGOs; and (3) notecard for brief description. With explaining about experimental procedure, every participant was asked to draw one or two pieces of GUI sketches. After the work was done, drawings were peeled off from the transparent adhesive paper and attached to the blank wall placed in the left-middle of simulation structure. And finally, they briefly described the reason of drawing with a certain intention.



**Figure 21:** After drawing a GUI on an adhesive drawing pad, then write its reason on a notecard.



**Figure 22:** Detach the drawing from the sketch pad, and attach it to the LEGO structure to see how it harmonizes with ambient environment.

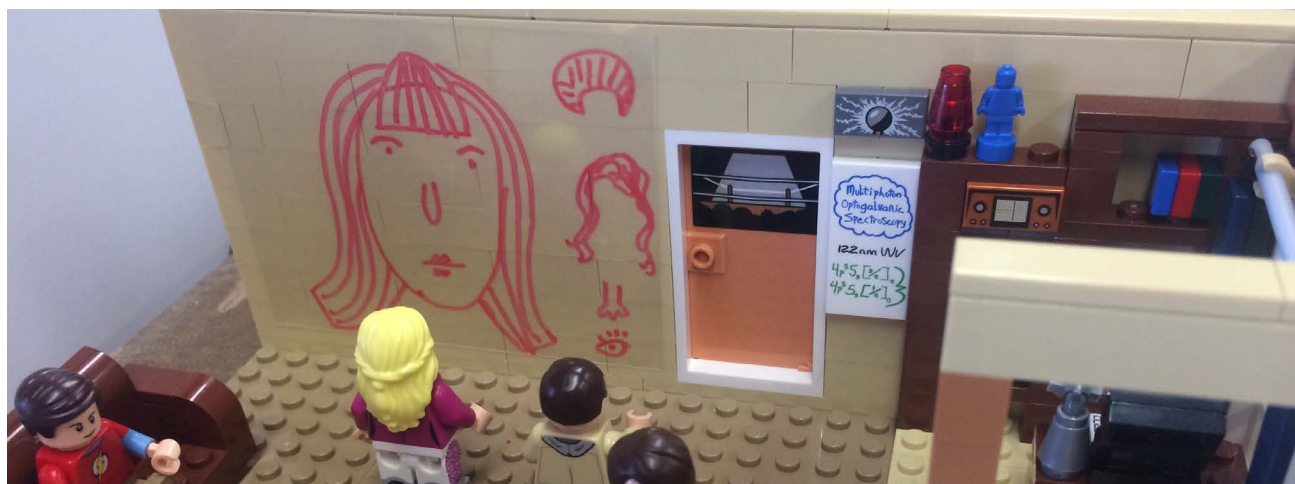
## Experiment procedure

### Participant 1



**Figure 23:** A GUI drawing which comprises interactive windows and puzzle patterned-wall

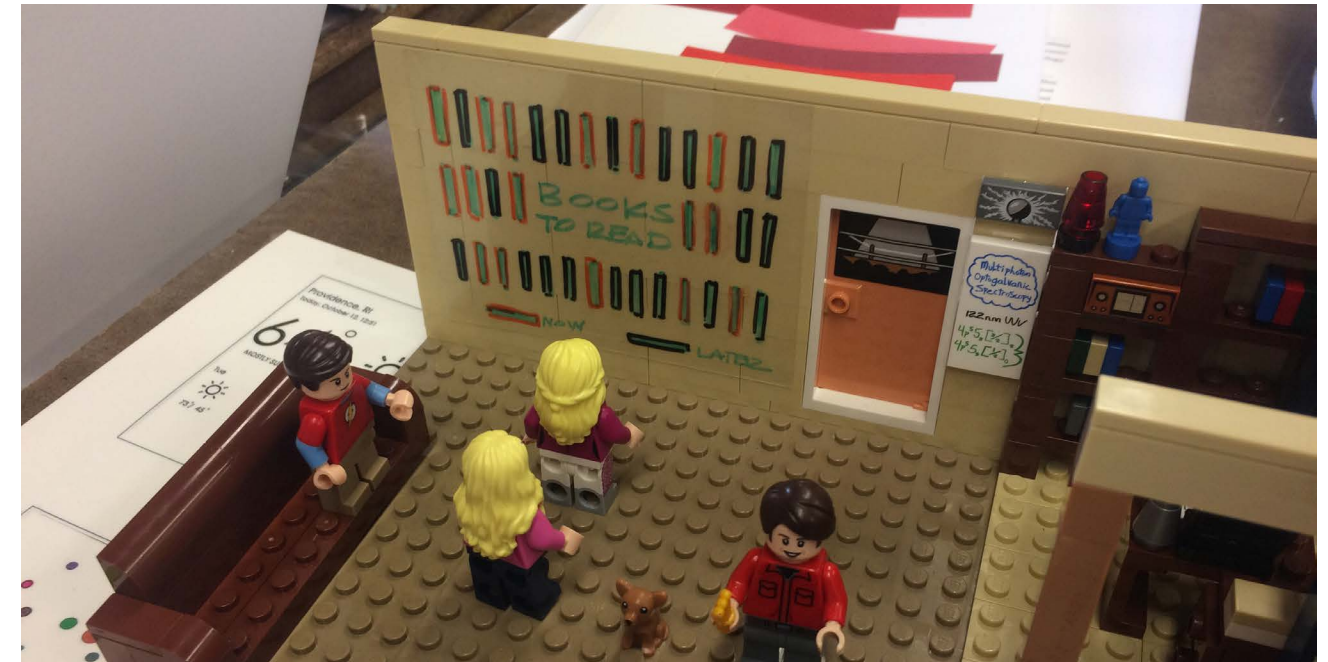
“ I really like to be in outdoor environment. So, I want to be able to see what is happening outside. It would be great if there is some kind of transparent puzzle on the wall, which is interactive when touching it.”



**Figure 24:** Virtual self makeover GUI

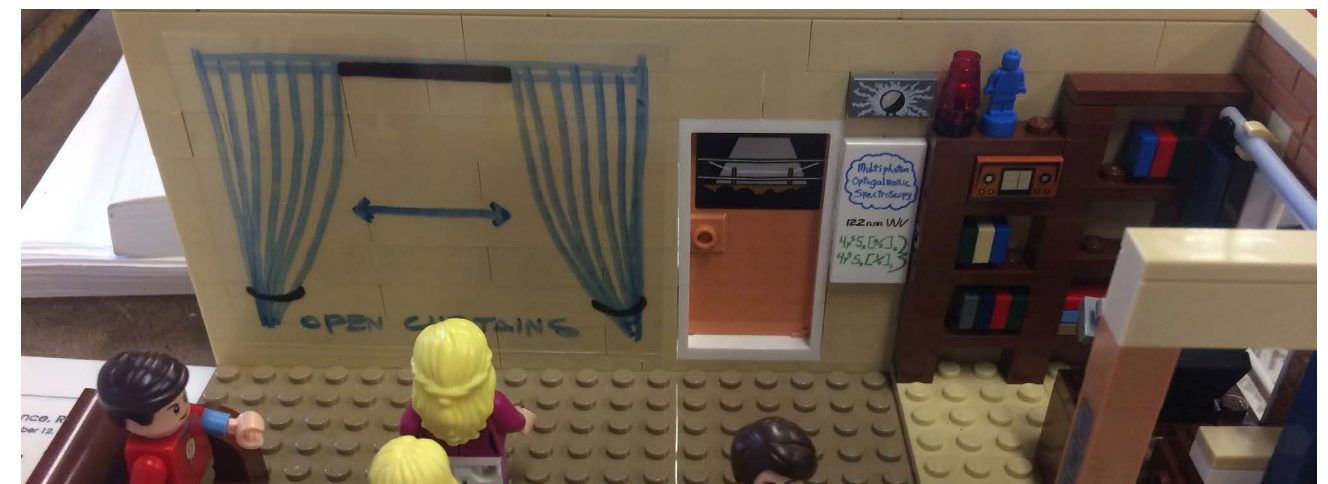
“ It would be funny if I can change my face.”

### Participant 2



**Figure 25:** Virtual bookshelf GUI

“Add a level of function to a library to know what information should be accessible at different points”



**Figure 26:** Digital curtain GUI. It virtually provides outside scenery with the gesture of opening the projected curtain

“Add to open curtains to let light in when I am sitting on the couch”

## Participant 3

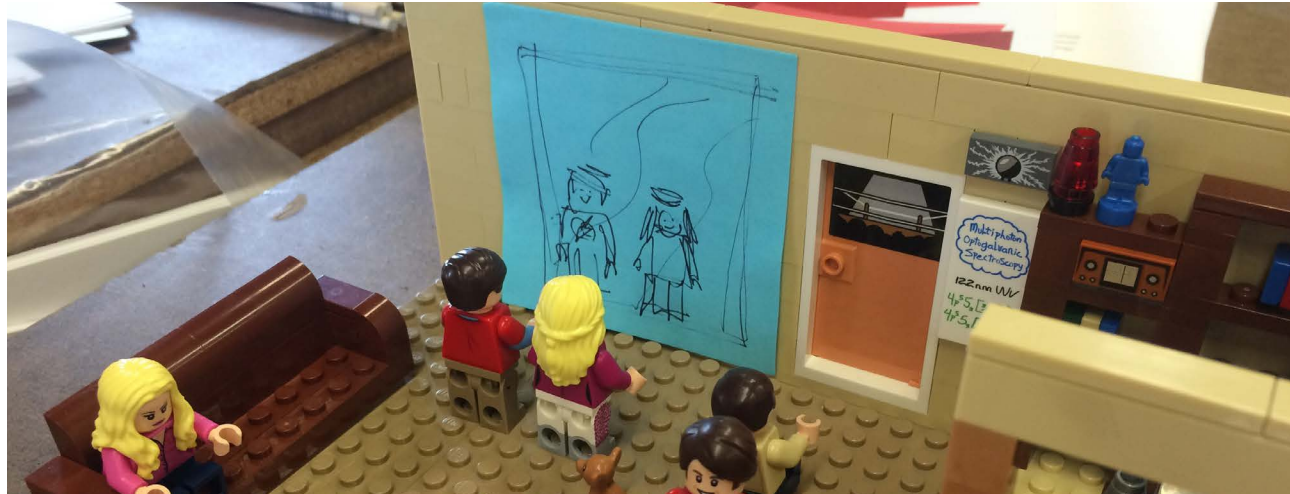


Figure 27: Virtual self costume GUI



Figure 28: (Top left) Virtual drawing pad GUI for kids who draw a sketch with crayons on the wall

Figure 29: (Top right) Interactive glittering disco lights GUI

Figure 30: (Lower left) GUI that tells user the estimated time arrival of user's spouse

Figure 31: (Lower right) User centered-commercial GUI that recommends optimal products expected to be suitable for user's living room

## Experimentation Insights

### Virtualizing physical objects' attributes

In the process of envisioning and customizing the augmented GUI applied to participants' environments, experimentation indicated a similar user propensity to it. That is, some people had a tendency of designing an augmented GUI derived from physical objects' features. As seen in **Figures 23, 25, and 26**, participants drew situations where they interplay with augmented GUI that virtually imitates physical objects' attributes. Related to the insights of **Chapter 2**, this chapter's experimentation also showed a possibility that the attribute the physical object originally contained could be translated into an augmented one in an interactive way.

### Importance of playful interactivity

From the experimentation, the vast majority of participants' works contextually contained similarities: In imagining the situation of interacting with augmented GUI in real life, what they drew shows that augmented graphics interactively react to users' activities or environments. For example, like **Figure 24's** and **27's** virtual costume play, people want to experience playful interactivity within their lives through technology.



## Chapter 4. Participatory experiment (2): Physical GUI applicability test and survey

### Exploring user's situational specificity

For this experiment, I contacted several classmates and faculties of MID studio and RISD and asked them to play with GUI stickers in their daily lives for approximately a week. The materials for the experiment were the same as **Chapter 3**. In observing participants' information propensity, I intended to see how they reorganize and recompose sample GUIs, depending on their situational specificities that deeply reflect on their daily lives. Through experimentation, several intriguing factors regarding behavioral patterns related to their situational specificities were discovered, and through those results, I have come to start envisioning how informative affordance of a thesis model should be planned.

**Figure 32:** Scenes of conducting an experiment: Peel off the GUI sticker, do the survey, attach it on the surface where participants feel to do so is a necessity.



## Experiment procedure

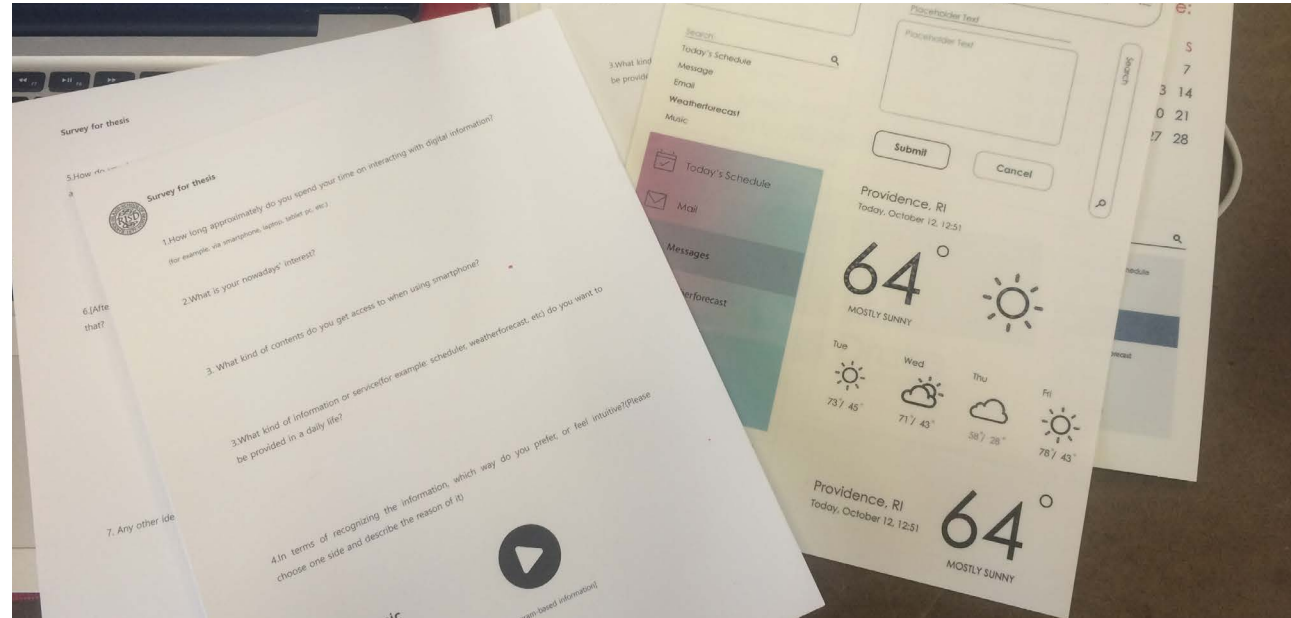


Figure 33: Survey paper and transparent GUI sticker set.

To introduce the procedure, an experiment is conducted as follows: participants were given two items, a survey paper and a transparent GUI sticker set. Two items were connected, and participants were asked to describe the survey while implementing the experiment of attaching stickers on objects (about half of participants engaged in the survey). For the method of playing with stickers, as shown in **Chapter 5**, all participants were encouraged to freely attach GUI stickers to wherever they wanted or speculatively felt was necessary.



Figure 34: In along with conducting experiment with GUI sticker, as mentioned, I also carried out a survey about personal preference and tendency of information usability via digital device like smartphone or laptop.

## Survey for personal propensity regarding consuming information

<Data below is what I collected from experiment survey>

### 1. How long approximately do you spend your time on interacting with digital information?(for example, via smartphone, laptop, tablet pc, etc)

- > "I spend most of my time on a computer or phone. And even when I am not, I usually listen to music or products on headphones. Working in the woodshop or socializing with friends are exceptions."
- > "3 hrs/day"
- > "2 hrs on smartphone/ 4hrs on laptop"
- > "Basically all the time. I write & work by using computer. I read, play games, and I use computer, phone, tablet to relax. I socialize with people via computer & phone."

### 2. What is your nowadays' interest" ?

- > "I have gotten interested in online dating lately and how that changes paradigms of social interactions, relationship growth I find, looking at profiles to be addictive, but actually interacting with people is more complicated."
- > "News, blogs(design, food, clothing, opinion, etc.), VOX/BBC/INYT/ New Yorke"
- > "Cycling, running, music, graphic design"
- > "Writing, infrastructure, design, games."

### 3. What kind of contents do you get access to when using smartphone?

- > "In the morning I am looking at the weather, the news, Instagram. During the day it is mostly playing music and google search, at night it is social media like Facebook, Instagram, CoffeeMeetsBagel."
- > "Messaging, news, email, video calling, websites, weather, camera,

photos, videos, maps, calendar, notes, reminders, music”

-> “Email, weather, Instagram, Strava(fitness traveling), Google search, Ebay, Talk&Text, camera, traffic/maps”

-> “Email, long articles, twitter, social media, videos, books, games”

#### **4. What kind of information or service(for example, scheduler, weatherforecast, etc) do you want to be provided in daily life?**

-> “To do lists, weather, clock, date of the month, emails.”

-> “Schedule, weather, multiple time zones”

-> “New places to eat, New routes in familiar area, construction/pot holes, forecast(next 4 hours), email sorting”

-> “Weather, grocery list, to-do list, recipes, play music”

#### **5. In terms of recognizing information, which way do you prefer, or feel intuitive?(Please choose one side and describe the reason)**

**Play the music**



**Text-based information**

**Pictogram-based information**

-> “It depends. For something, this is universal that it is pictogram. For anything more specific, a pictogram is maybe too ambiguous. I want to make sure the button I press is going to do what I want.”

-> “[Chosed pictogram based-information] If it is more intuitive, an image is nicer to look at/conveys more words in an image.”

-> “[Chosed pictogram based-information]”

-> “[chosed both]”

#### **6. How do you feel about what if GUI(Graphic User Interface) co-exists with physical environments as a way of augmented reality?(Is it helpful, or disruptive to your life? Or else?)**

-> “It could be either helpful or disruptive. I think it should respond to the mental state I am in. Likfe if I am really focused, I will not want interruptions, but if i have been focusing for 3 hours I probably need a distraction. I do think shared augmented reality could be very powerful because it is hard to share an experience with someone else if it is just on your phone screen.”

-> “Helpful, but sometimes unnecessary.”

-> “I would like it in a small ways. I do not need for heavy duty tasks...”

-> “Feel it might be intrusive, I am constantly clearing notifications from my phone./ would corrupt physical environment if design(type/concept/etc) was not appropriate to surroundings / light from display?”

## Participatory experiment

### Participant 1



**Figure 35:** Calendar GUI attached on the desk.

"This is the calendar. I put it on my home desk. I want it to sync with my studio desk so I always know what deadlines are coming up, regardless of which desk I'm sitting at."



**Figure 36:** Weatherforecast GUI attached near bed.

"This is the weather. I want it to be on the shelf next to my bed. When I wake up I can look forward to a sunny day. I also sometimes sit here while I'm thinking of what to wear. This is my relaxing spot. Weather is pretty benign information so I don't mind it being next to my sleeping spot. This



**Figure 37:** Meeting-schedule GUI attached on the wall near kitchen to easily verify in morning.

"This is where I drink my coffee in the morning. I wouldn't mind checking my itinerary here."



**Figure 38:** Music player GUI sticker on the surface of a refrigerator in the case of having a party in that area.

"This is our embarrassing refrigerator. Don't mind the underwear models. This is where my roommates and I hang out and sometimes party. It might be cool to control the music on a surface we all own, rather than a device that belongs to just one of us."



**Figure 39:** Lock screen GUI for setting off fire alarm when cooking

"This is the thing that sets off our fire alarms all the time. Maybe we could speed dial our landlord to let him know that the house isn't burning down, we're just making pancakes. Maybe he could come enjoys some pancakes with us."



**Figure 40:** Schedule-menu GUI attached on a bathroom mirror

"This is our bathroom. I brush my teeth here. It's kind of boring, so why not check up on the weather forecast? I don't know how I would interact with this interface though..."

Participant 2



Figure 41: Various application of GUIs in RISD MID studio

“ I thought it would be interesting to have information about my schedule on one side of my desk and information about my music or something else on the opposite side. This way the information remains organized and is more easily accessible. I also put the large weather sticker on the window because that way I would be able to see how the weather looks outside and the temperature value at the same time “



Figure 42: Small sized-weatherforecast GUI and music blog GUI attached near bedside

“Here are the ones I put at my place. I felt it might be interesting to have some information close to the bed. This way, when I wake up I can immediately see what the weather forecast is. The entertainment could be interesting to control the tv or music while I'm relaxing in bed or to put some music on while I get ready in the morning. “

Participant 3



**Figure 43:** Bunch of SNS icons attached on the mirror( To presume his intention, he intended to post daily self-looking on SNS as a daily self-documentation through clicking the icon attached right on the mirror)

Participant 4



**Figure 46:** Note GUI attached on the counter

“This is a text entry for adding groceries to my grocery list for when I am cooking and notice I am almost out of something. This is a situation where I cannot use the phone easily because my fingers are often messy and I am in a rush. So it would be nice to be able to type on the counter.”



**Figure 44:** (Left) Weather forecast GUI attached on the window  
**Figure 45:** (Right) Weather forecast GUI attached near thermometer



**Figure 47:** Note GUI attached on the side of refrigerator

“This is another place where I often think of something when I am in a rush and my hands are wet or messy so being able to add items to the grocery list here would be good.”



**Figure 48:** Weather forecast GUI attached near bedside

"This is so I can wake up and see the weather first thing without getting my phone out."



**Figure 50:** Music player GUI attached under table

"This is the idea of controlling the music at dinner without being disruptive to the diner guests. It is subtle."



**Figure 49:** Weatherforecast GUI attached near hanger

"This is for when I am dressing to leave the house I can check the weather while my hands are full of bags/coats."



**Figure 51:** Weatherforecast GUI attached near makeup counter

"It might be better to know the weather when looking at the closet and makeup counter."



**Figure 52:** Simplified weather forecast GUI attached near entrance

“This is the idea of glancing at the weather when going out doors.”

“So based on the experiment and talking it over with someone, I think that the moments we most wanted the interface in the wall was moments when:

- we were in a rush
- or our hands were full or messy
- or when pulling out a phone would be rude or disruptive

I like the possibilities of more subtle interactions where we don't have to dig into our pockets for phones.”

## Experimentation Insights

### Consideration on informative affordance in terms of usability

In daily life, people perceive diverse versions of information via various types of mediums, particularly, in accessing information via smart devices. Depending on how UX structure of application is planned, users' informative recognition is influenced. Moreover, as I dealt with **Chapter 1**'s user behavioral pattern under situational specificity, under a certain situation that demands a quick solution, user's accessibility on information becomes limitative.

In this experiment, as an experimental expansion on applying augmented information to an external physical environment, participants' implementations in their actual lives indicate that informative affordance plays an important part in terms of perceiving proper quality and quantity of information in an actual environment. Similar to **Chapter 2**'s insights, depending on the site and situational specificity participants had, the volume and content of GUI were differently considered, and according to that intention, the informative affordance was correspondingly changed. For instance, as seen from **Figure 50** and **Figure 52**, in a certain situation, like verifying weather right before going out or playing music while having a dinner, it is legitimate that informative affordance is required to be designed in a way of simplifying the sequence of perceiving and manipulating the information. On the other hand, as in **Figure 42**'s GUI near the bedside, GUI that relatively contains a densified information structure is acceptable in a situation of having proper time to look at it. Given this chapter's results, informational flexibility reflecting on users' external circumstances needs to be considered as a milestone in developing user scenario of augmented GUI.



## Chapter 5. Projecting augmented GUI in real environment

### Simulating Augmented GUI in an Actual Environment

In constructing augmented GUI, which could be applied to actual environment as a utilitarian medium, what I mainly focused on in this chapter was how augmented GUI collaborates with an external environment under a certain situational specificity. As discovered from **Chapter 4**, depending on attributes the external environment contains, information accessibility or perceptibility could be influenced. In particular, for a user who needs instant information, like checking weather before going out, compact information that accommodates to his situational specificity is required to that moment.

To discover its actual usability I started to prototype several types of augmented GUI and attempted to simulate them onto actual surfaces in a daily life.

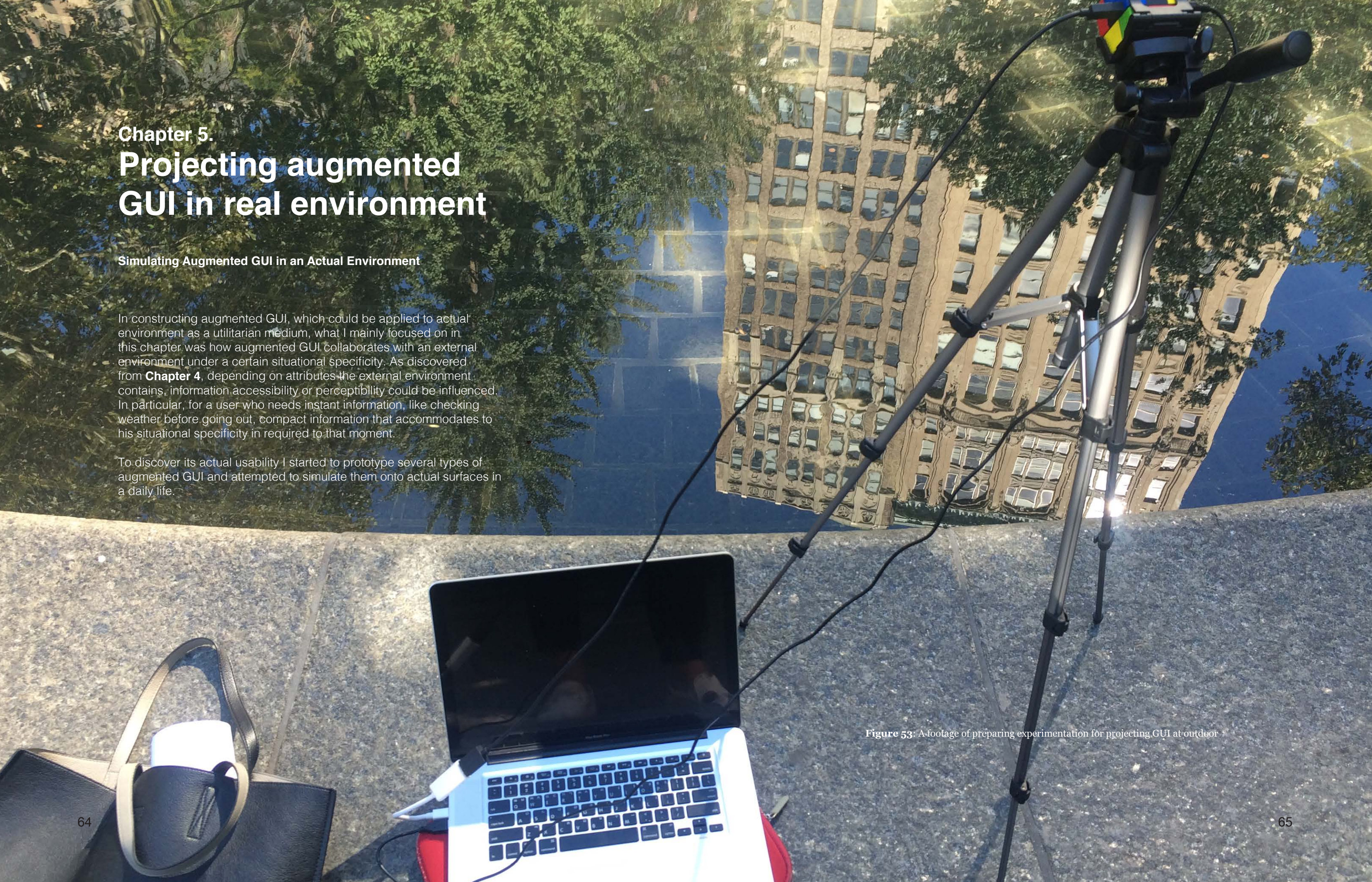


Figure 53: A footage of preparing experimentation for projecting GUI at outdoor

**Pilot Demo:  
Small-Size Simulation via LEGO  
Interior**

Prior to implementing experimentation, as a playful simulation, I utilized the LEGO interior set I used in the previous chapter and projected a simple movable GUI on the LEGO wall to speculate how graphic interaction applied to the physical environment.

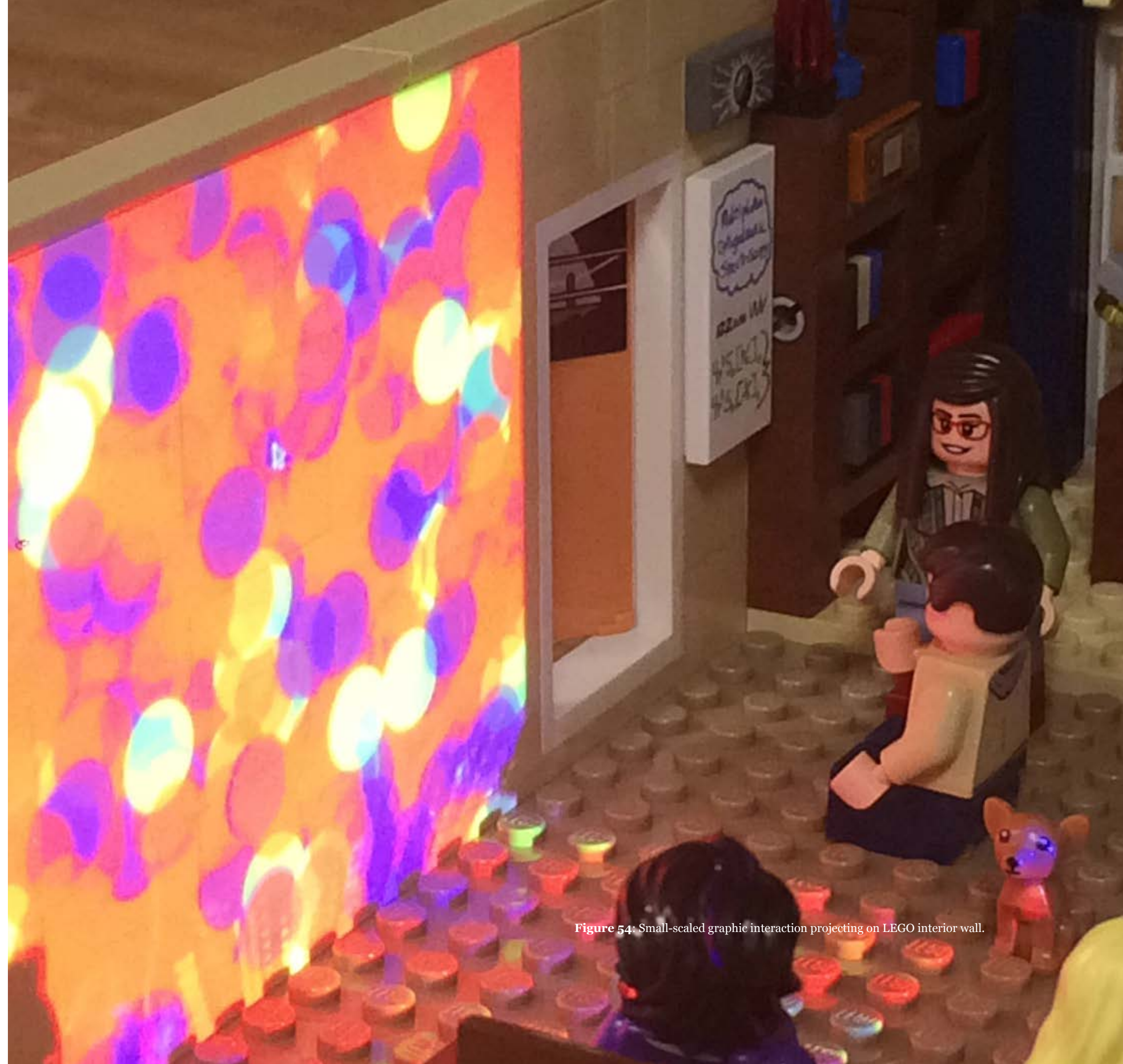
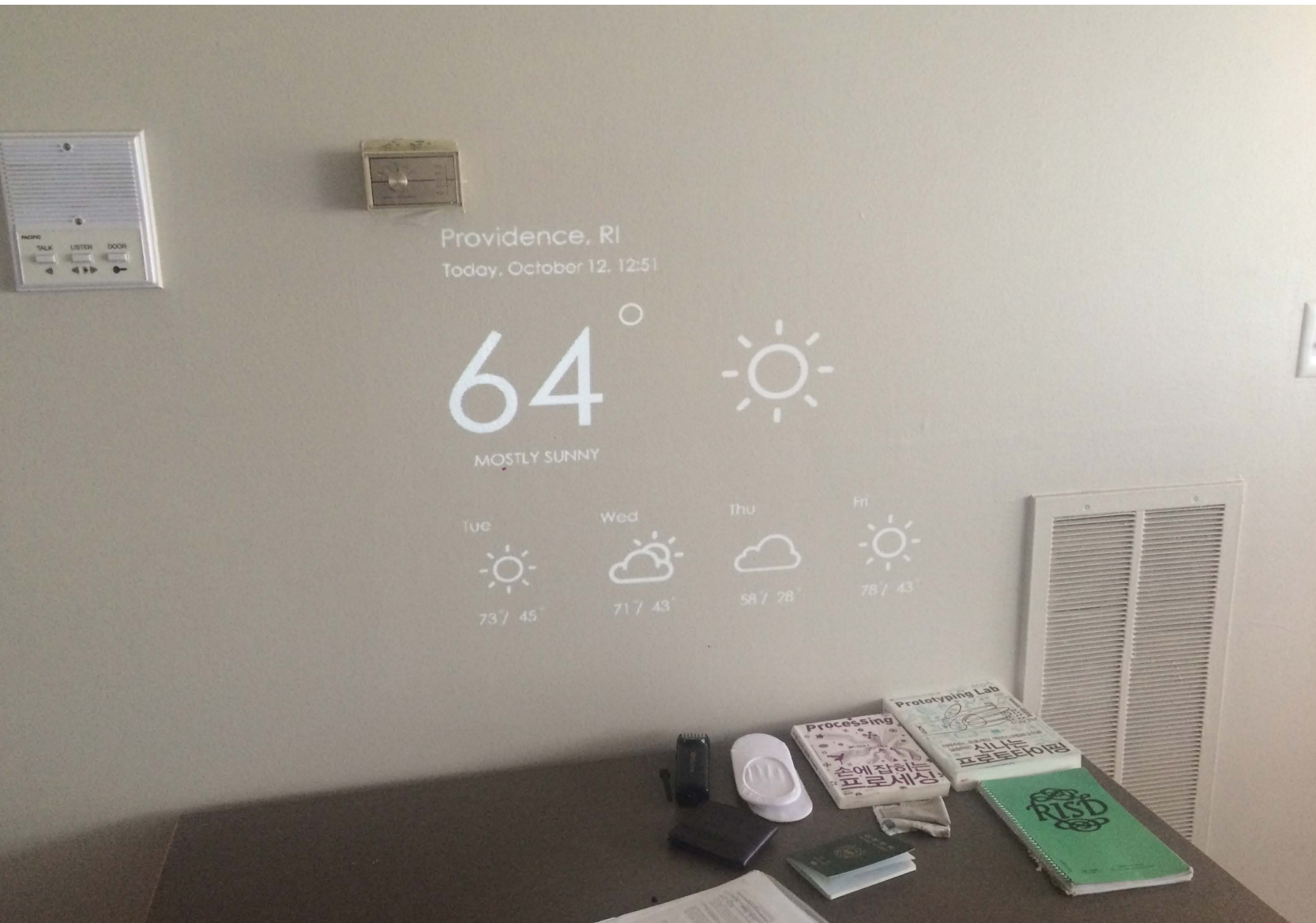


Figure 54: Small-scaled graphic interaction projecting on LEGO interior wall.

**Case 1: Informative GUI in daily life - weather forecast GUI**



**Figure 55:** The weather forecast GUI was projected on the wall where the desk is near. I assume the situation of verifying weather while doing something on the desk.

For simulating a weather forecast GUI, I hypothetically suppose the situation of being in need of verifying weather right on the verge of going out. Walls near a desk and entrance door and a bathroom wall were considered as platforms for simulation.



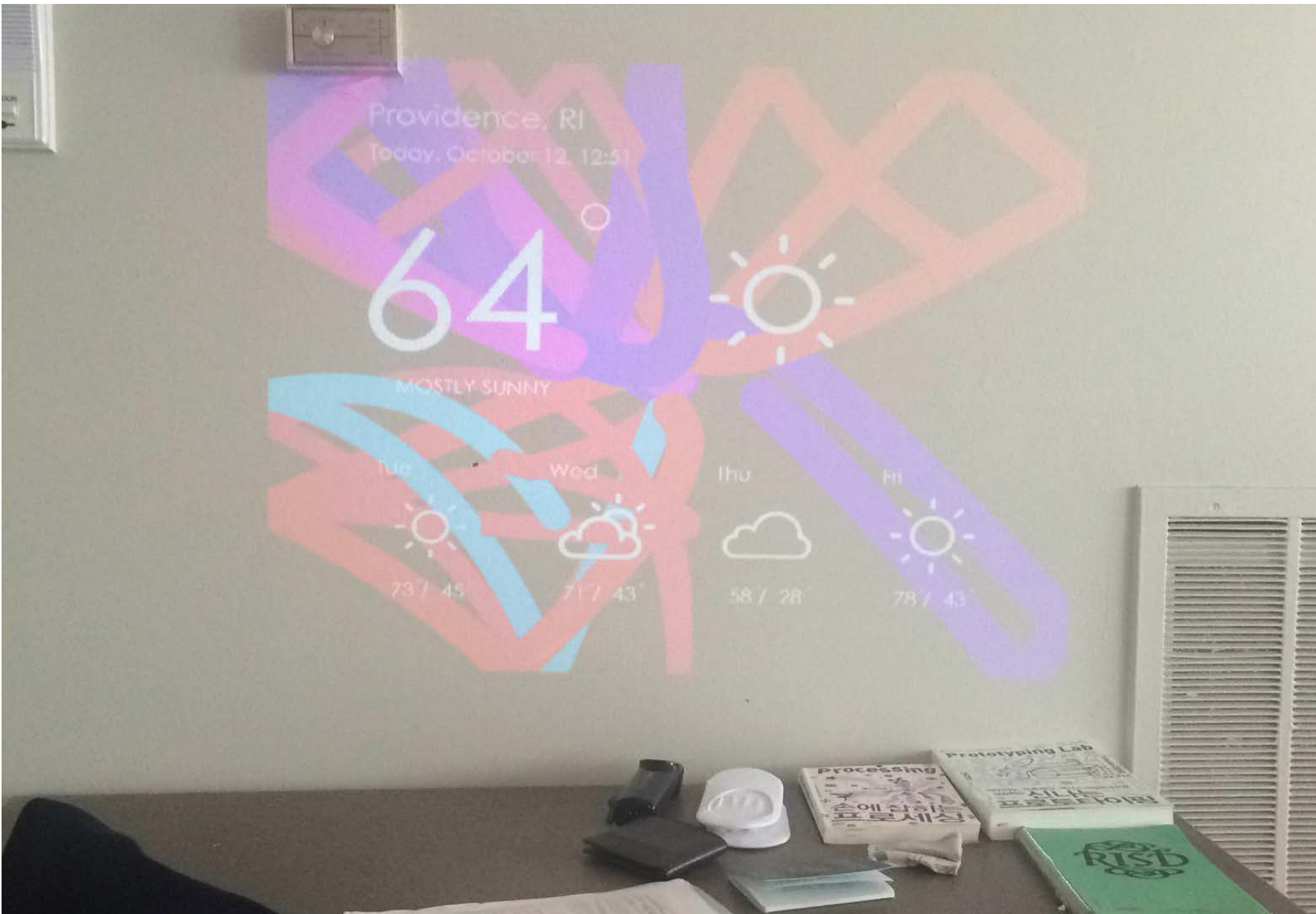
**Figure 56:** Augmented weather forecast GUI on the entrance door



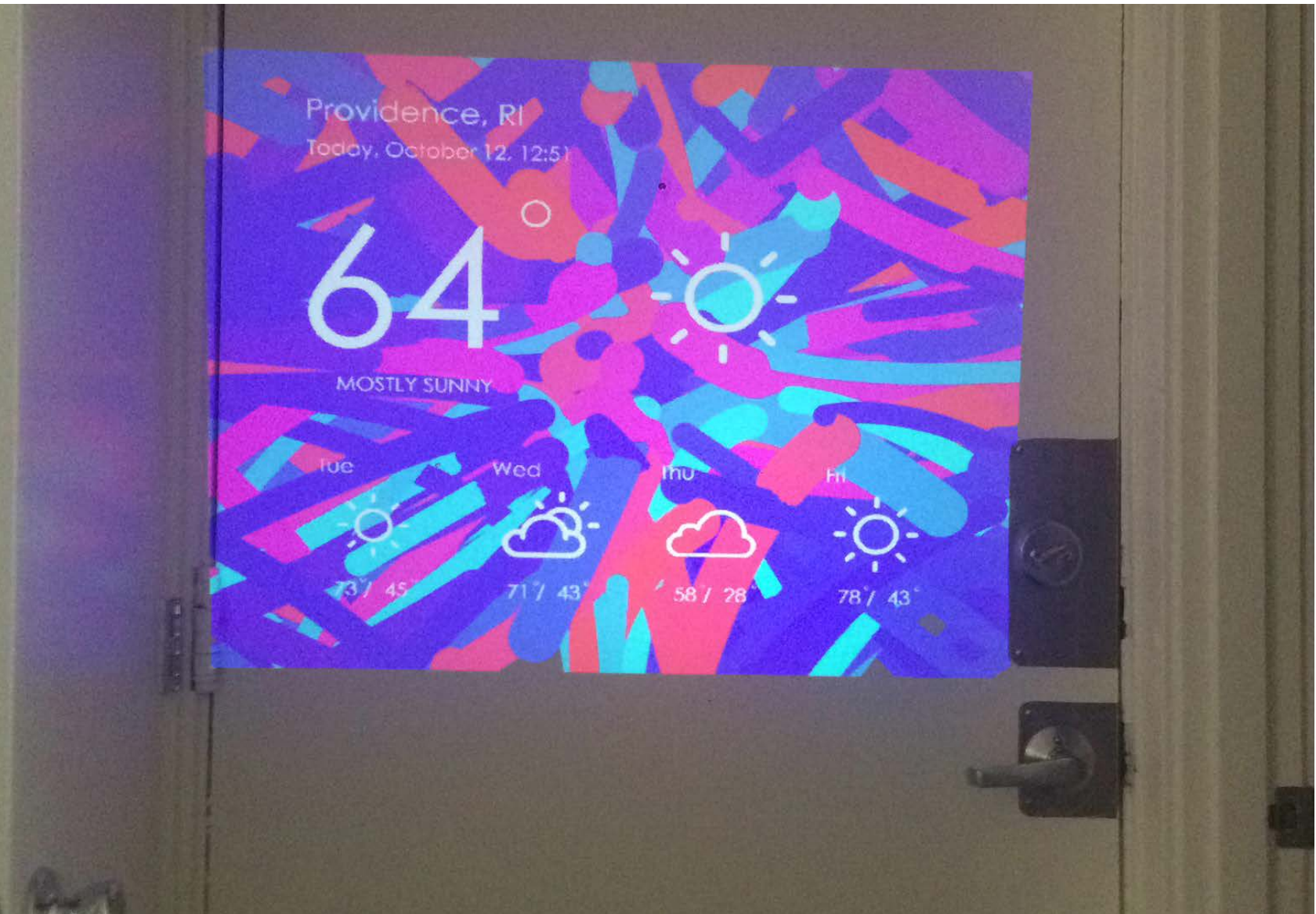
**Figure 57 :** Augmented weather forecast GUI on the bathroom wall

**Case 2: Informative GUI combined with graphic interaction**

In designing augmented GUI comprising multiple layers of information, like an application combined with graphic interaction, considering how much space graphic interaction occupies and displays within an application was important in terms of appropriate information accessibility. Moreover, depending on the external environment like space or lighting conditions, user information recognition was highly influenced.



**Figure 58:** I programmed to add movable graphic interaction to weather forecast information to test how the perceptibility changes by it.



**Figure 59:** Another attempt on an entrance door

### Case 3: Visual interaction as status signage

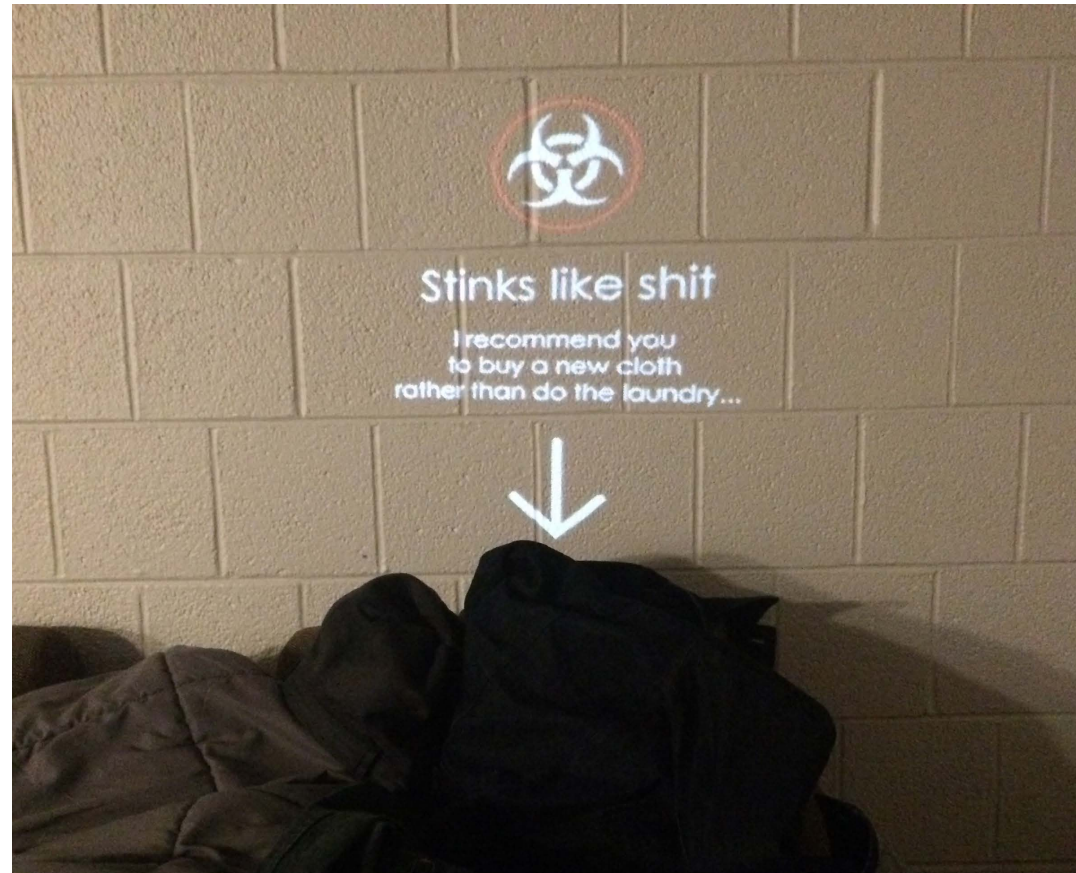


Figure 60: Augmented GUI whether sarcastically alerting or encouraging user to deal with laundries

In expanding the speculative usage of interactive interfaces that interplay with the physical environment, I figured out another possibility of being playful in this space. In desinging the interaction, I thought of the idea that it contains humorous attributes that encourage users to vigorously participate in what they used to avoid in their daily lives. For my example, I do not usually do laundry every week because I have had some thoughts like, "I have been busy with experimenting and documenting for a few weeks. My blanket is starting to stink, my white clothes are stained, but it would be alright to postpone doing laundry to the following week." Inspired by this experience, as the graphic shows in **Figure 60**, I envisioned the usability that GUI humorously warns users to deal with what they feel reluctant to do.

### Case 4: Visual interaction with music player



Figure 61: The color of sound wave changes into different colors in correspondence with the next song's tone.

In this simulation, I assumed a situation where the user interactively controls the augmented music player virtually displaying on the wall without any smart devices. With augmented control of function, sound visualization plays in the way of responding to music the user chose. Also, depending on music tone or genre the user listens to, the sound wave's color turns into a different color.

### Case 5: Augmented social application for cooking

Noticeably, getting access to an SNS (social network service, e.g., Facebook, Instagram, Twitter, etc.) at any time is becoming a very common thing in our lives. To get a “like” on Facebook or to just share an experience with someone, we document our moments in life and upload it to them.

Related to that phenomenon of simultaneously capturing the moment of what they are doing even while doing it, I speculatively simulated a situation of sharing a cooking experiences with friends via SNS icons. In **Figure 62**, augmented GUI displays verbal interactions embedded with a bunch of commonly used SNS icons. During the process of cooking, users interactively interplay with augmented GUI’s verbal reaction to your cooking and can simultaneously get access to SNS to share your actions with friends.



Figure 62: Augmented social GUI reciprocally reactive to user’s cooking.



## Chapter 6. Prototyping sequential GUI interaction on surface

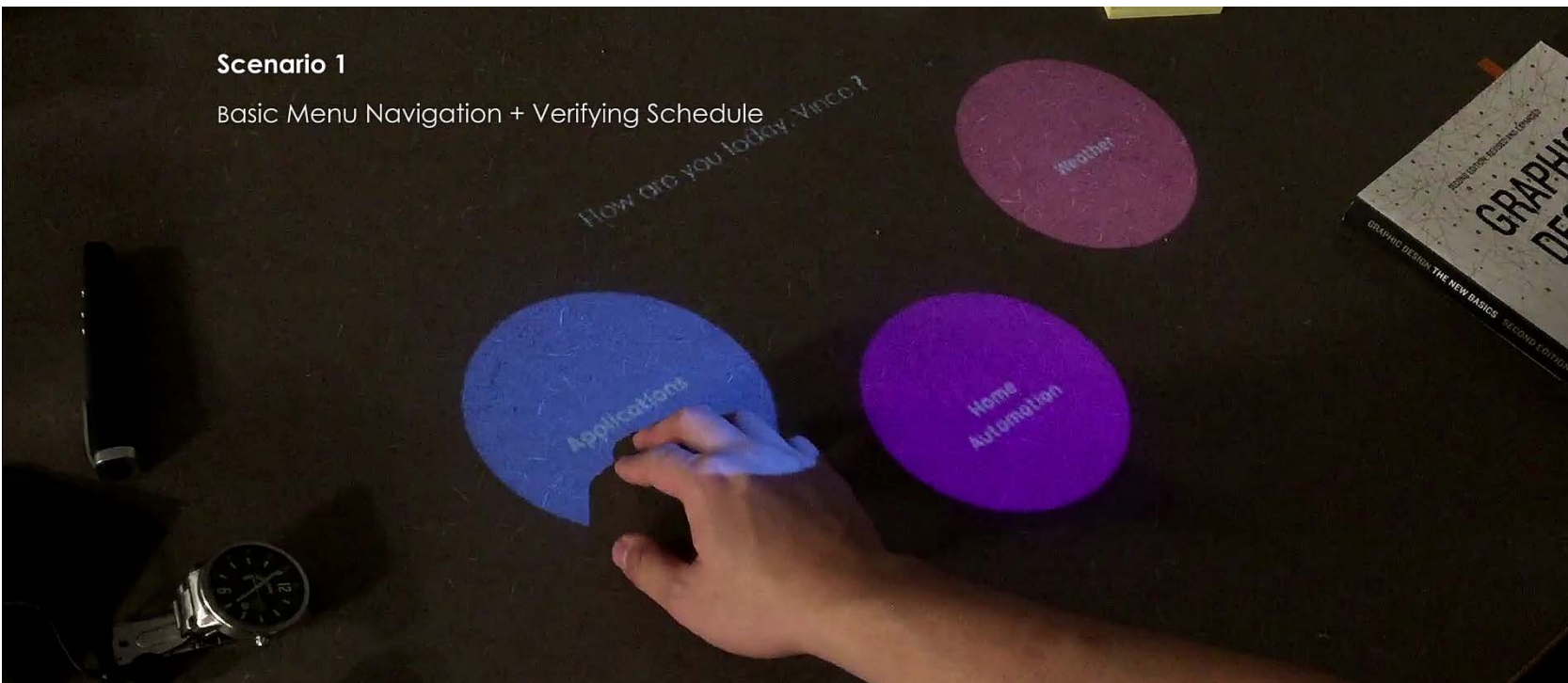
### Simulating user scenario of augmented GUI

As a continuous, theoretical extension for actualizing augmented GUI combined with a physical surface, in this stage, I started to develop the concept of designing sequential interaction in GUI combined with a work-table surface. I utilized Adobe's After Effect for making sequences of how graphic motions are occurring and reacting in a certain way by tactile action, like physically tapping on the surface. By using a projection-mapping technique in simulating the prototyping, I deliberately acted in actually navigating application projecting on the surface with the purpose of recognizing the interactivity and affordance applications GUI contains.

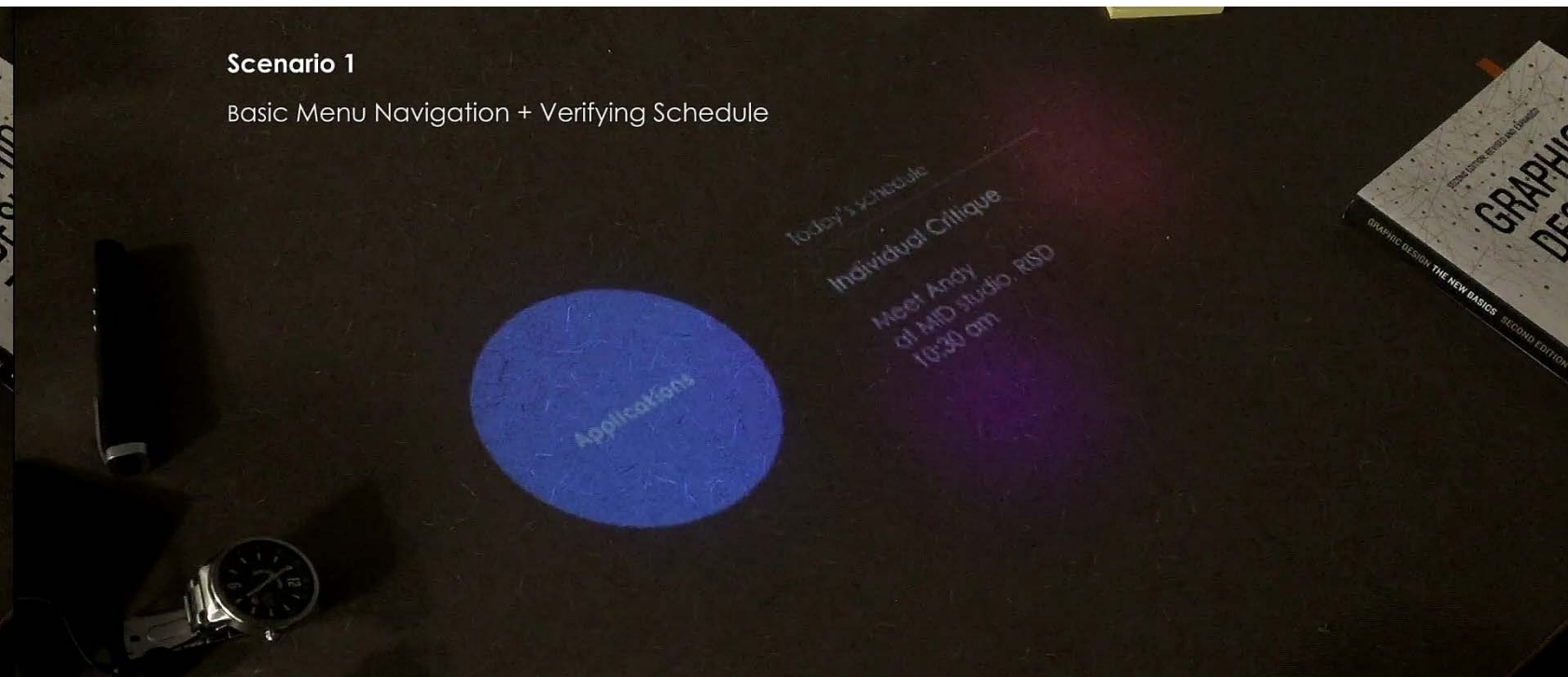
Figure 63: A scene of projecting the GUI onto a surface

**Scenario 0:  
Simplifying the start sequence of GUI**

**Scenario 1:  
Verifying today's schedule**

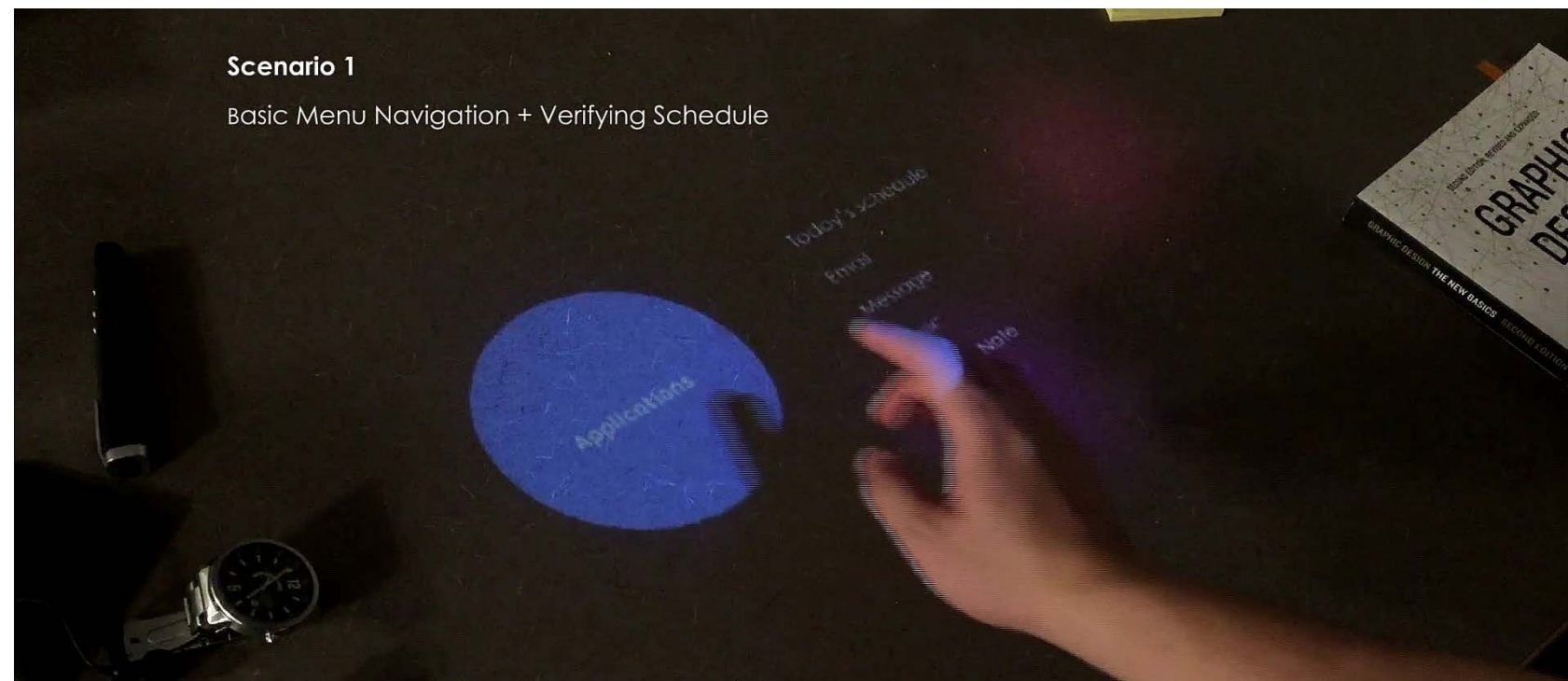


**Figure 64:** Start page of augmented scheduler GUI.



**Figure 65 - 1:** Navigating side menu within application menu(e.g. Today's schedule, Email, Message, Music, Weather Forecast etc.)

In designing informative sequence structure for augmented GUI as an initial step, as found in the HCI analysis phase, constructing sequential GUI structures based on user-centered usability was essential in terms of sustaining the degree of information affordance. Particularly in designing and prototyping the GUI of the scheduler app as a way of actualizing via augmented reality, I considered the anticipated usability of augmented GUI relating to actual environment. Distinctive to typical informative sequences that a mobile or web application has, I took reference of the UI structure of an interactive table regarding interplay with users by interactive surface embedded with GUI. Initiated from this way of approach, I designed the starting sequence of augmented GUI consisting of simplified menus with simplified graphics. Also, with the point of communicating with the user in an augmented GUI, I attempted to layout interactive comments above the GUIs like "How are you today, XXXX?"

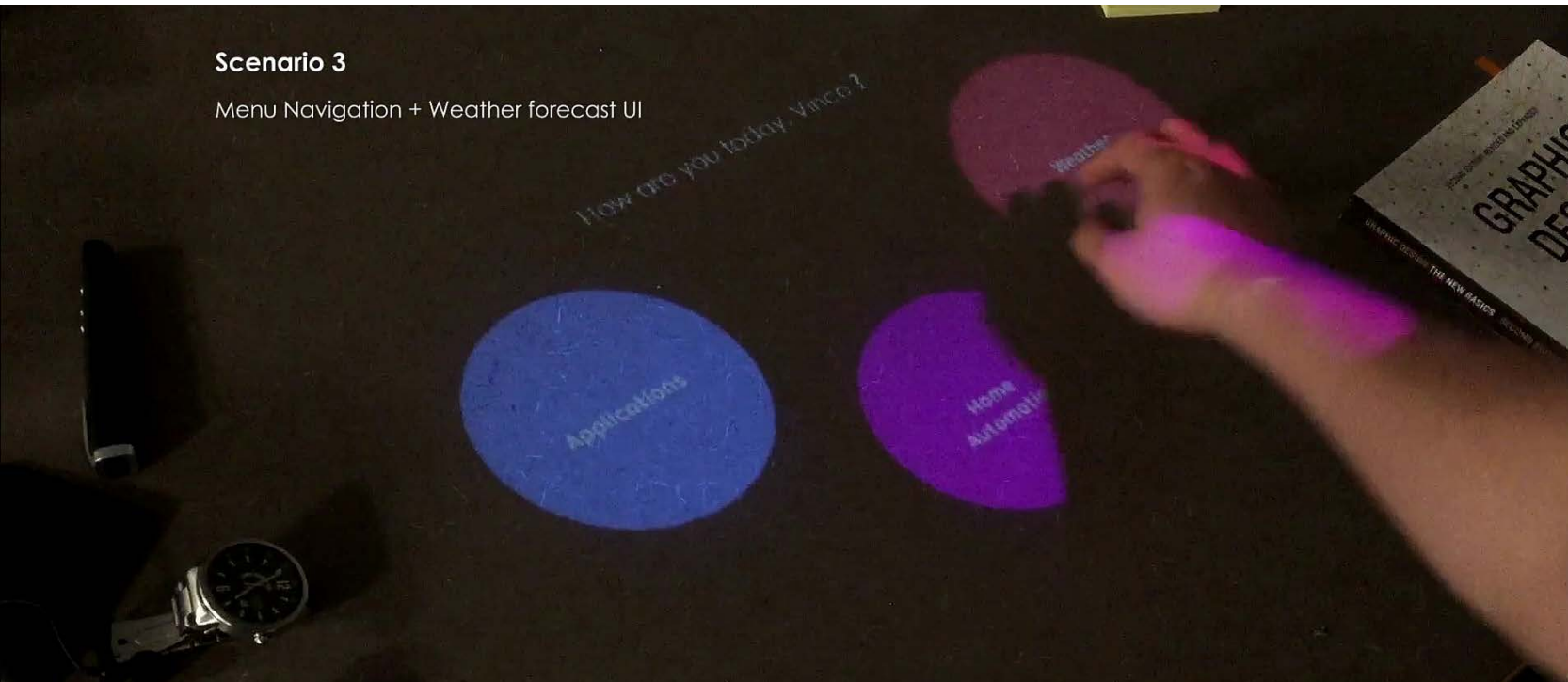
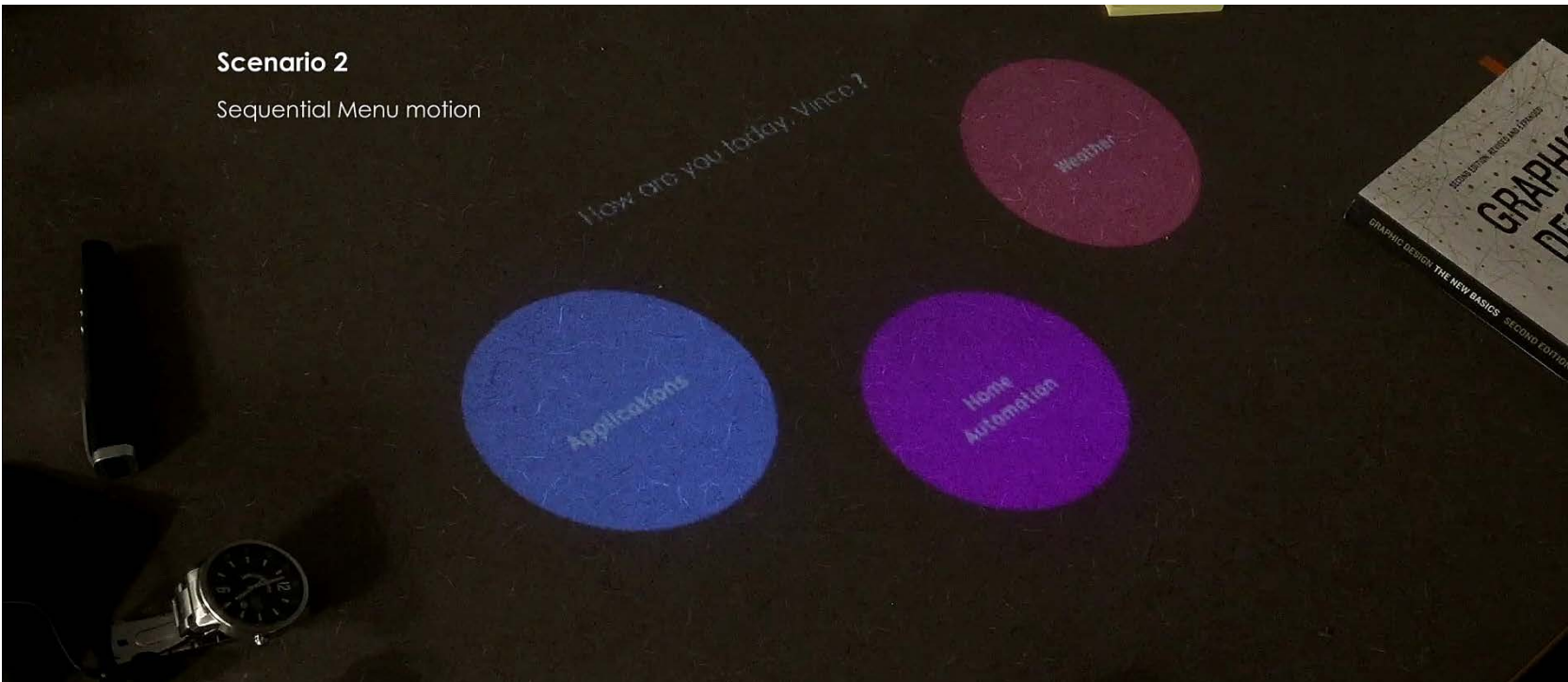


**Figure 65 - 2:** When user tap on application menu, side menu smoothly pop-ups besides it. And then user clicks "Today's Schedule" menu, schedule shows up, and user can toss it to the corner of table just as putting sticky notes on the side of it. User thus can verify the schedule whenever interacting with augmented table.



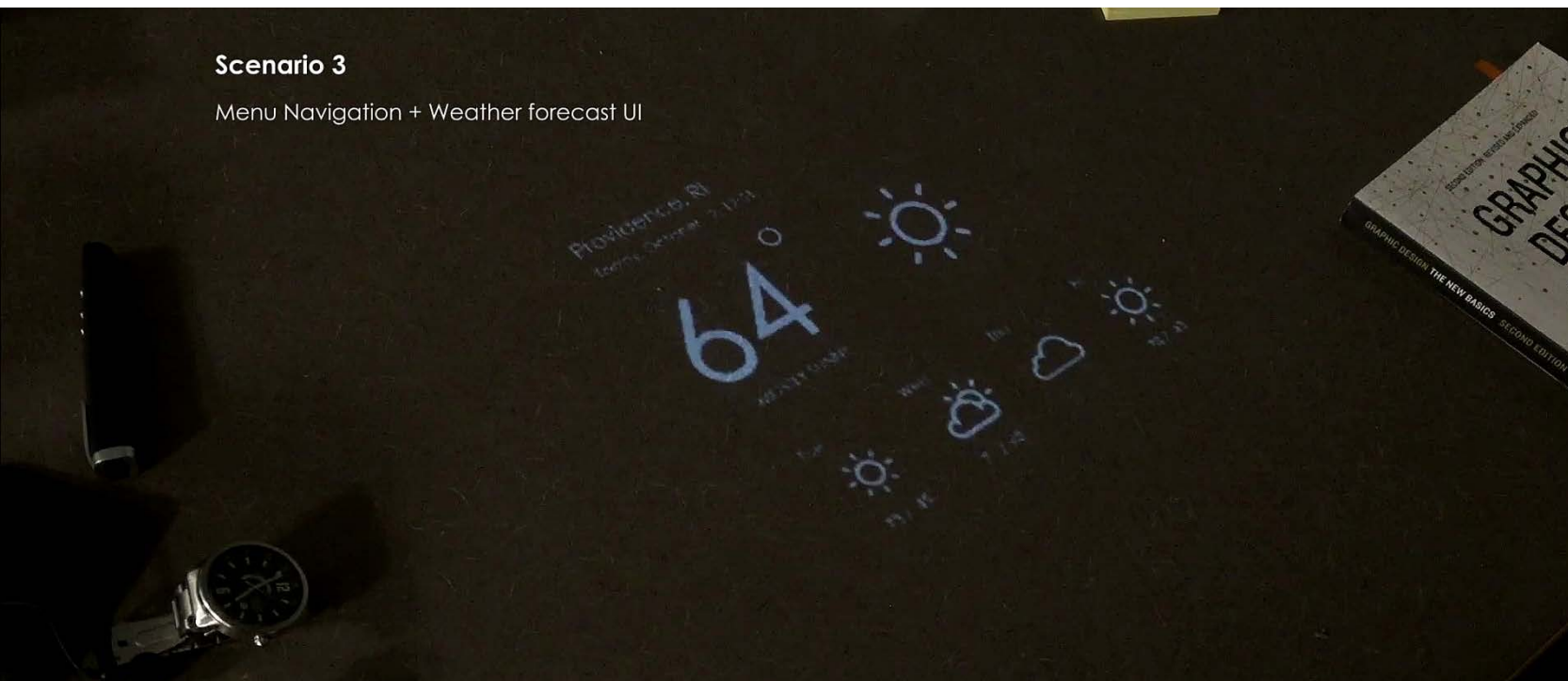
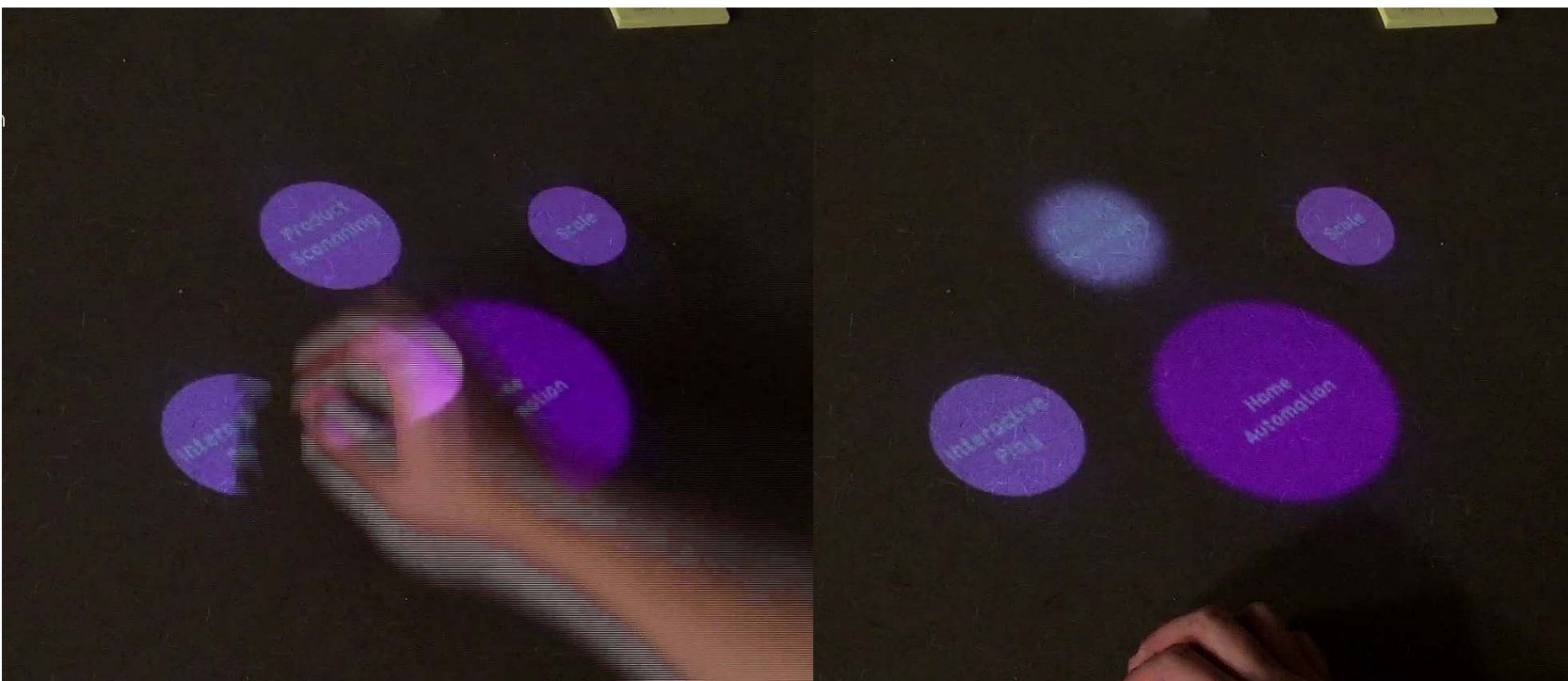
**Scenario 2:  
Graphic interaction of sub-menu**

**Scenario 3:  
Menu navigation + Weather forecast GUI**



**Figure 66 - 1:** Start page of Scheduler GUI

**Figure 67 - 1:** After clicking the sub-menu "Today's schedule", user verifies the information



**Figure 66 - 2:** In a sense of unifying the graphical metaphor of GUI, I continuously extended its concept into designing graphic interaction of sub-menu. As shown in the lower left picture, sub-menu smoothly appears when user taps on the main menu circle. After clicking sub-menu, it opaquely illuminates, and whole page then turn out to be a chosen page/application

**Figure 67 - 2:** Real-time weather forecast GUI is displayed on the surface. Beside of getting access to it by clicking the menu, I thought of different accessibility, such as weather forecast GUI is reactable to user's approach to the table by motion sensor which detects human approach

### Scenario 4: Transferring text from mobile device to augmented surface

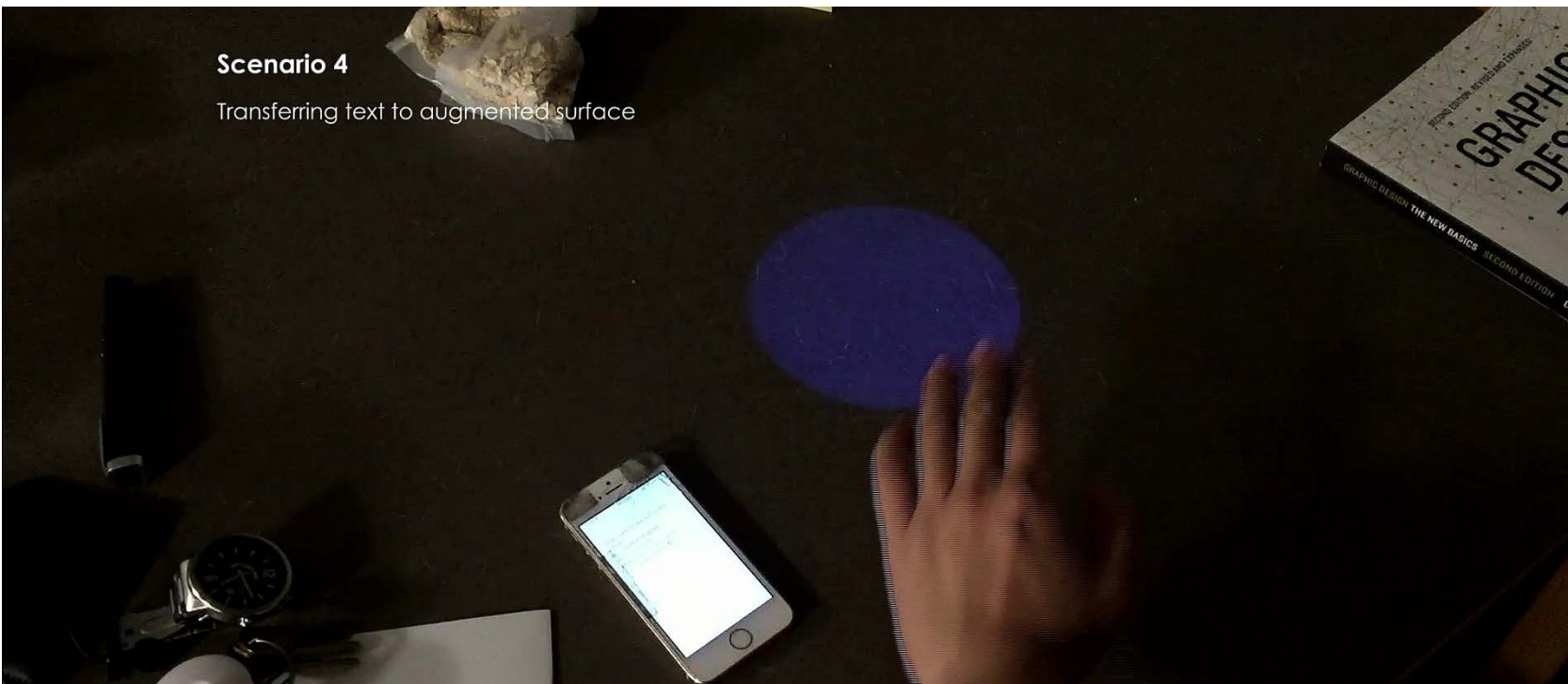


Figure 68 - 1: In order to transfer the text to an augmented surface, do the gesture of swiping the phone screen towards the table. And then blue circle appears in the middle

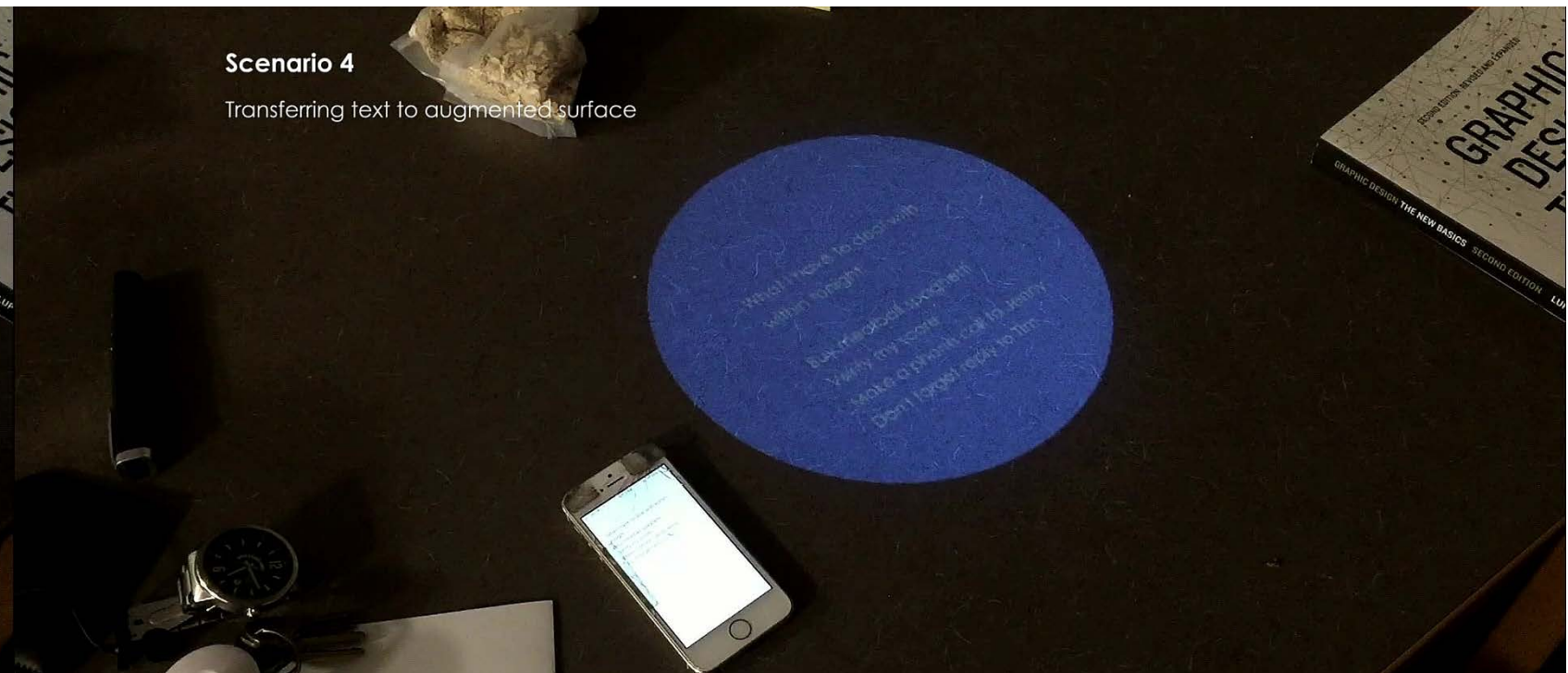


Figure 68 - 3: Soon, the text user wrote via mobile phone appears in a blue circle

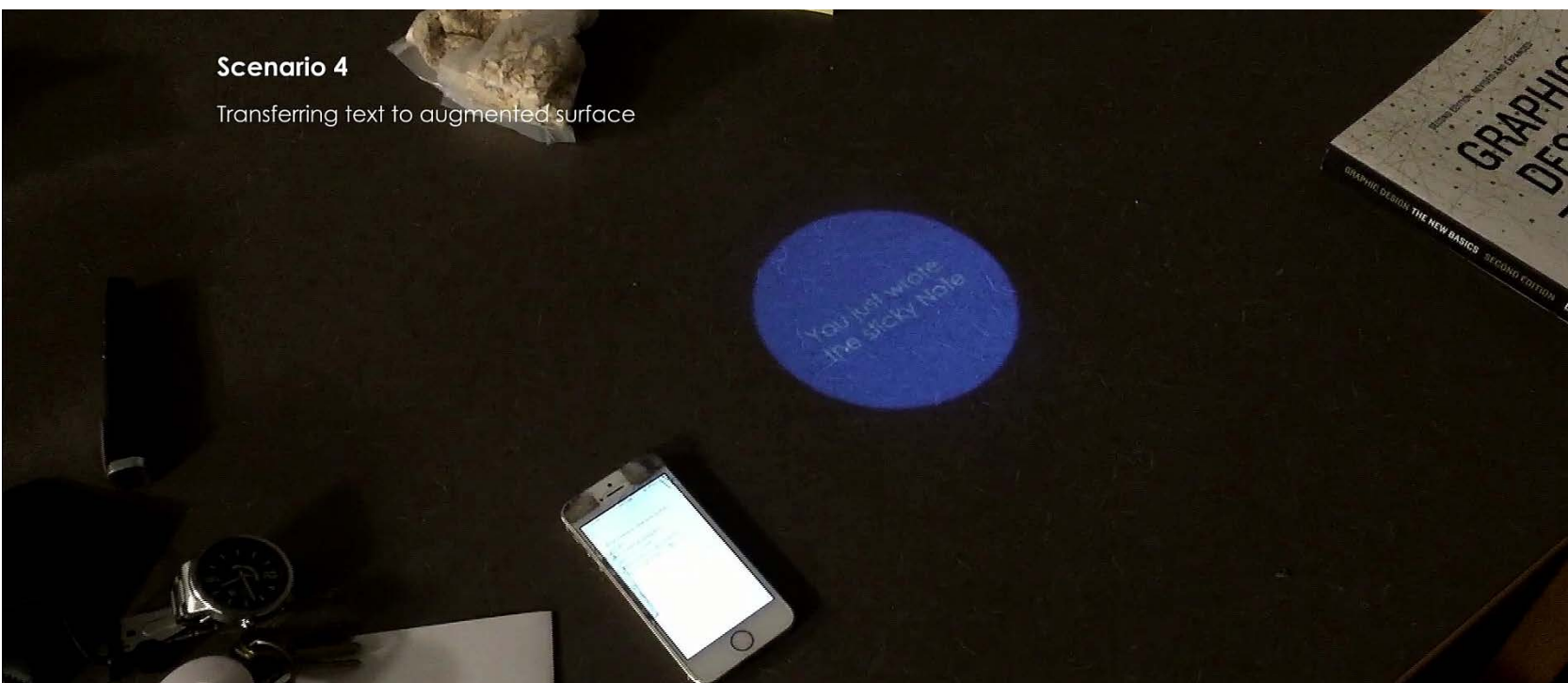


Figure 68 - 2: In the blue circle, user recognizes the message as a meaning of confirmation for receiving text from mobile device: "You just wrote the sticky note"

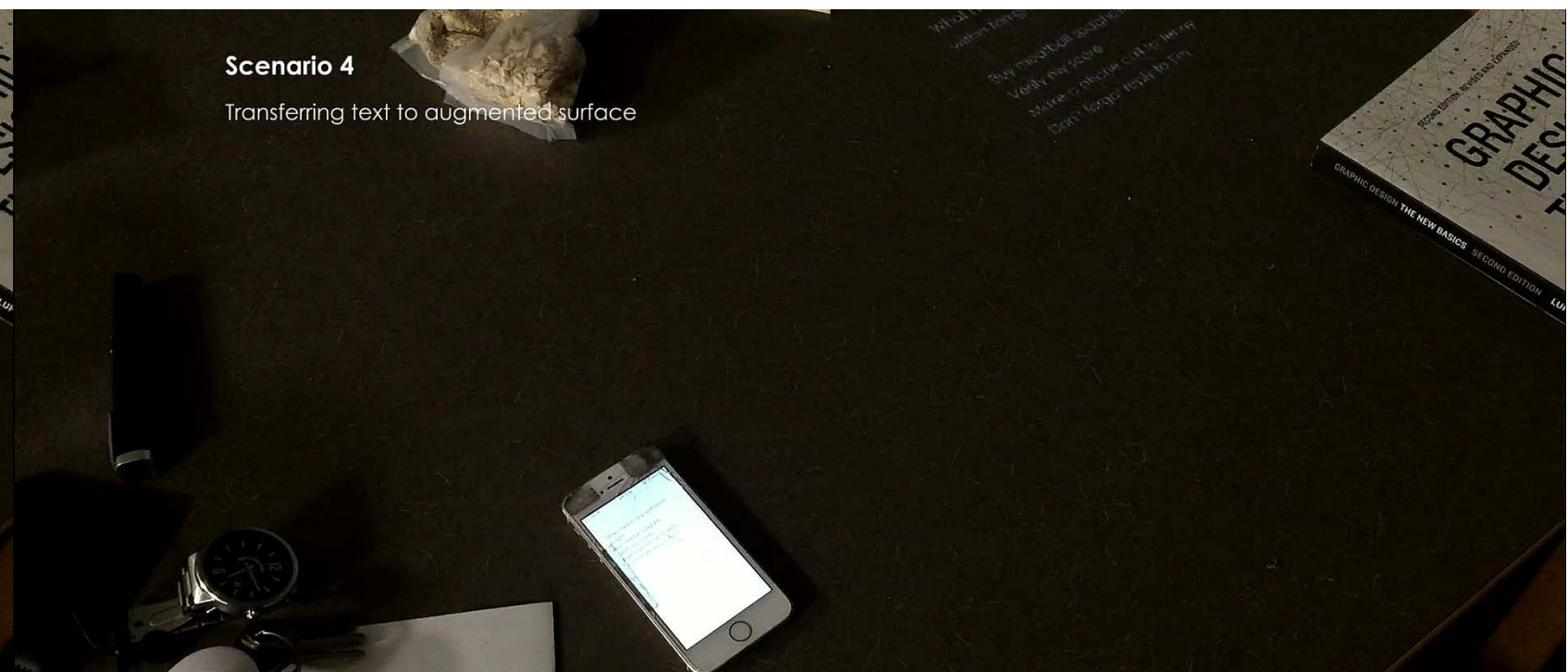
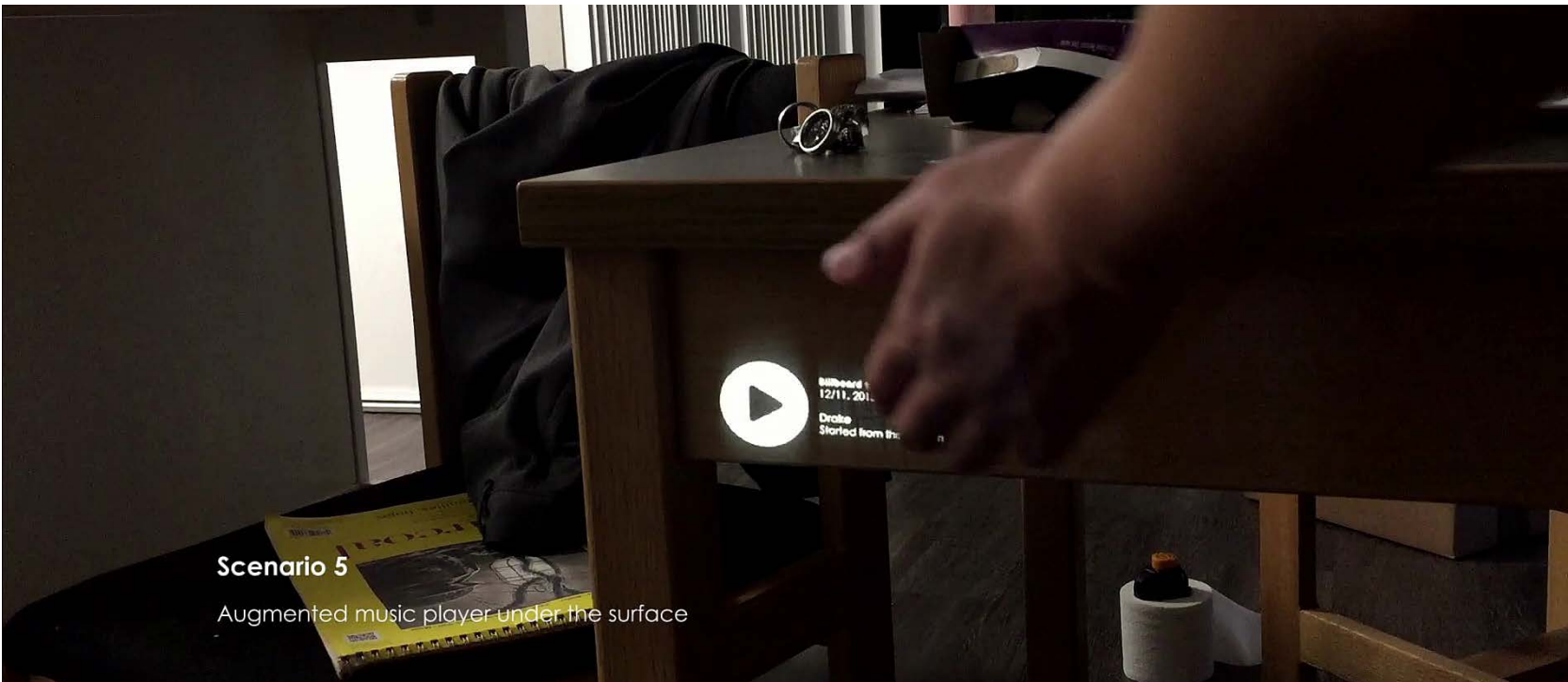


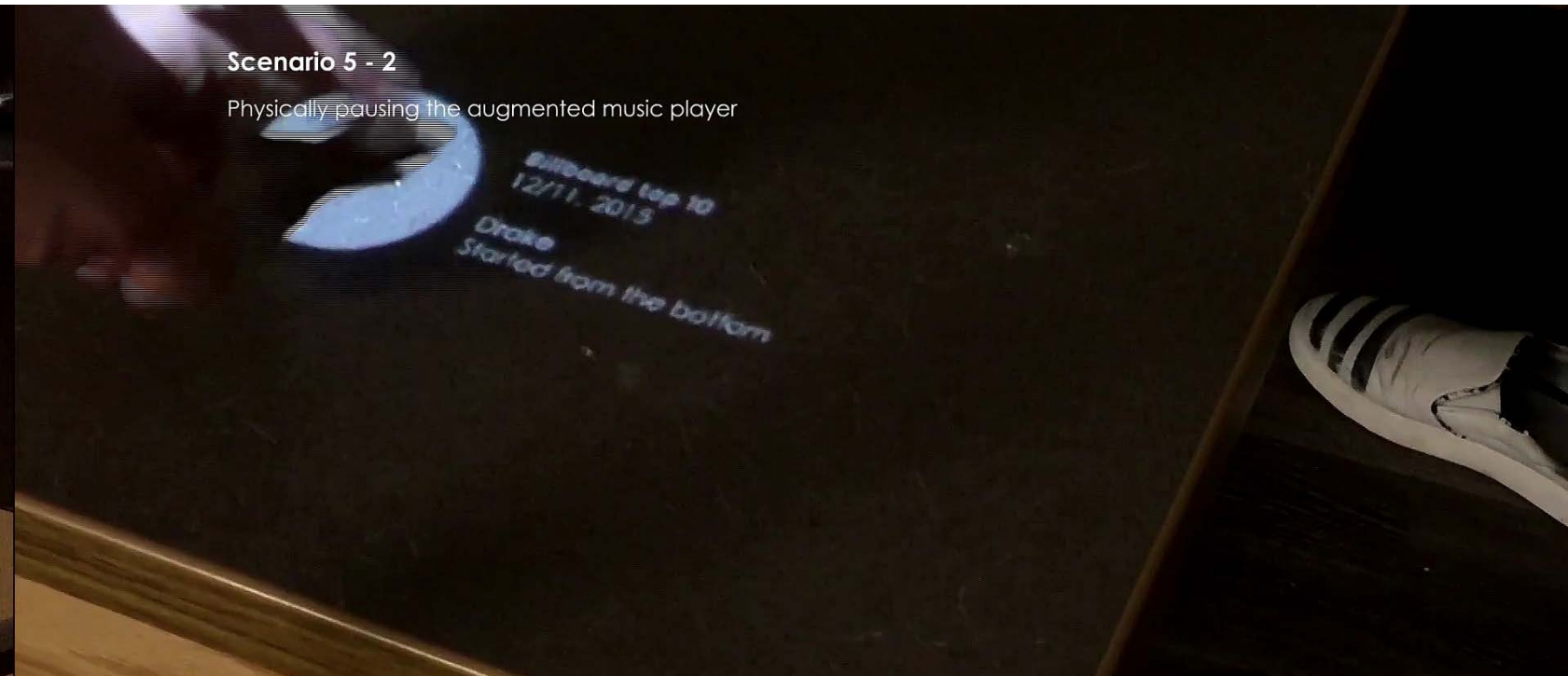
Figure 68 - 4: And then a blue circle disappears, augmented text is moved to the corner of the table. Same as Scenario 1's scheduler in the corner, I intended the situation of collecting and preserving information in the side of work space, just as attaching sticky notes on the refrigerator

**Scenario 5:  
Augmented Music player placed within reach**



**Figure 69 - 1:** What if we turn on the music while having a dinner on the table?

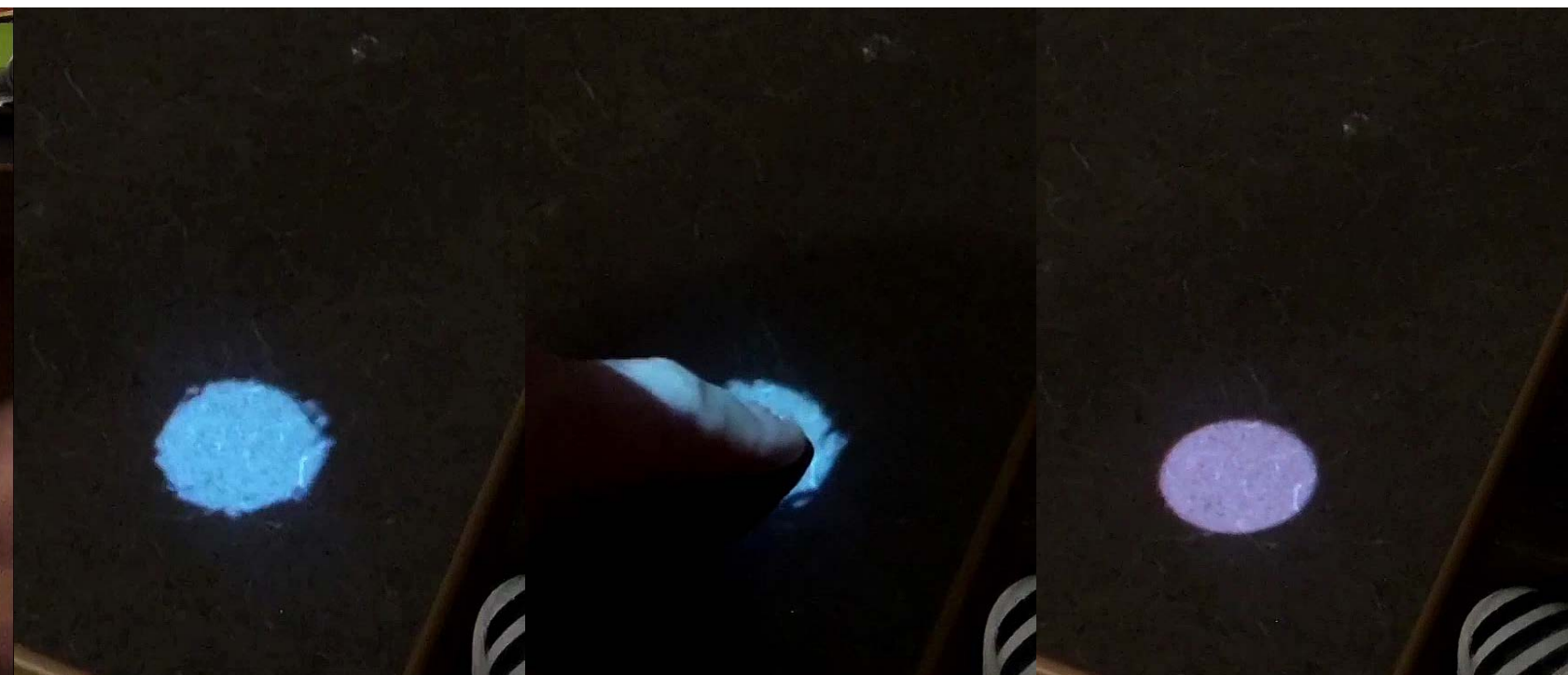
**Scenario 5 - 2:  
Augmented Music player with augmented stop button**



**Figure 70 - 1:** Same as Scenario 5's music player, user turns on the music by clicking icon

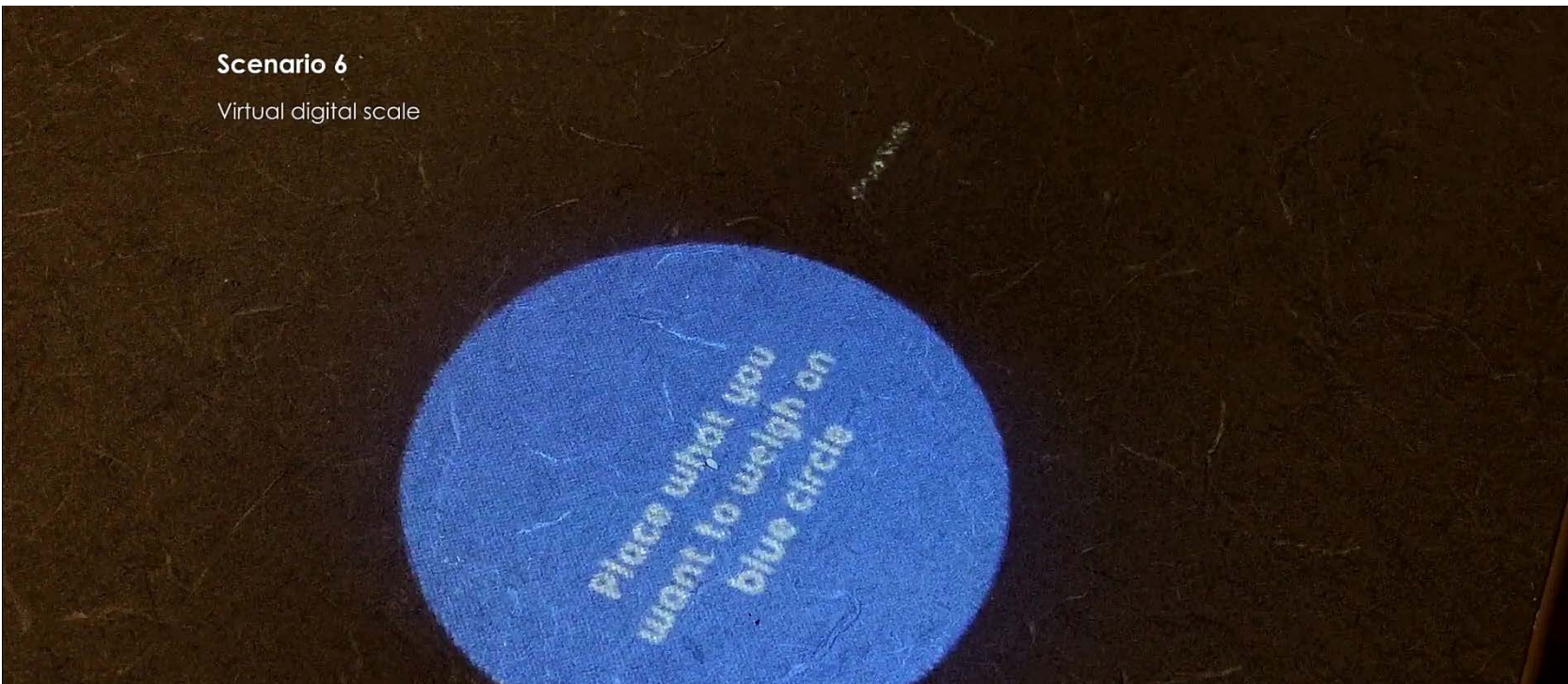


**Figure 69 - 2:** when clicking play button, it reacts in opaquely glowing and music is played



**Figure 70 - 2:** (Left) When the music is turned on, default GUI disappears, and a small blue circle appears on the corner of the table. For this blue circle, it represents that the music is on / (Middle) If in need of turning off the music, user clicks the blue circle / (Right) After clicking, it turns out into red one representing that the music is off.

**Scenario 6:  
Virtual digital scale**

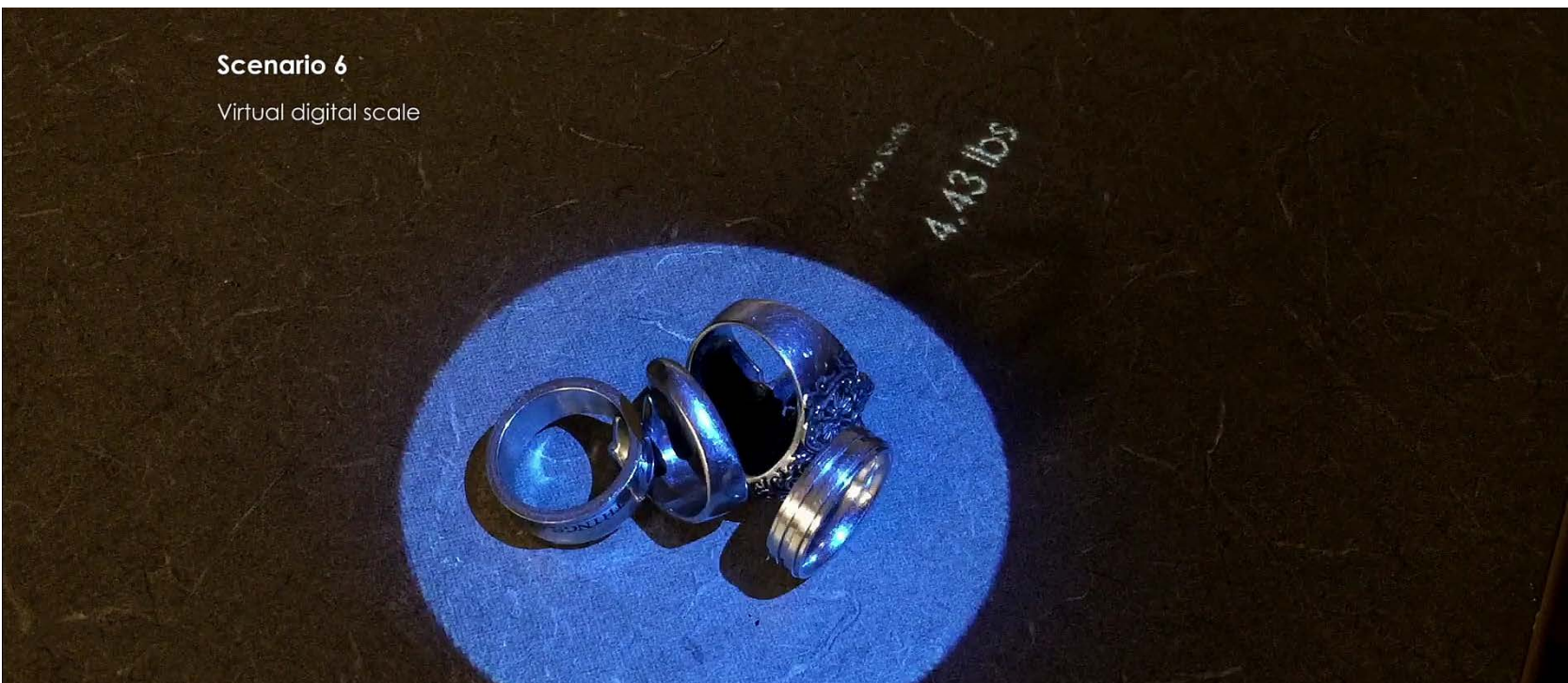


**Figure 71 - 1:** To measure the weight, user gets access to application, turns on a blue circle with text, "place what you want to weigh on blue circle", which augmentedly measures the weight by sensor under the surface.

**Scenario 7:  
Autonomous object recognition**



**Figure 72 - 1:** In daily life, user occasionally puts his belongings on the table with no any reason



**Figure 71 - 2:** After putting objects onto a blue circle, then it displays how much it weighs as a picture above



**Figure 72 - 2:** Depending on what the object is or how important to user as personal belongings, table recognizes its existence in an augmented visualization, and simultaneously displays relevant information around objects. Due to this effect, user can whether keep remembering or preserve the information regarding personal object whenever putting it on the table

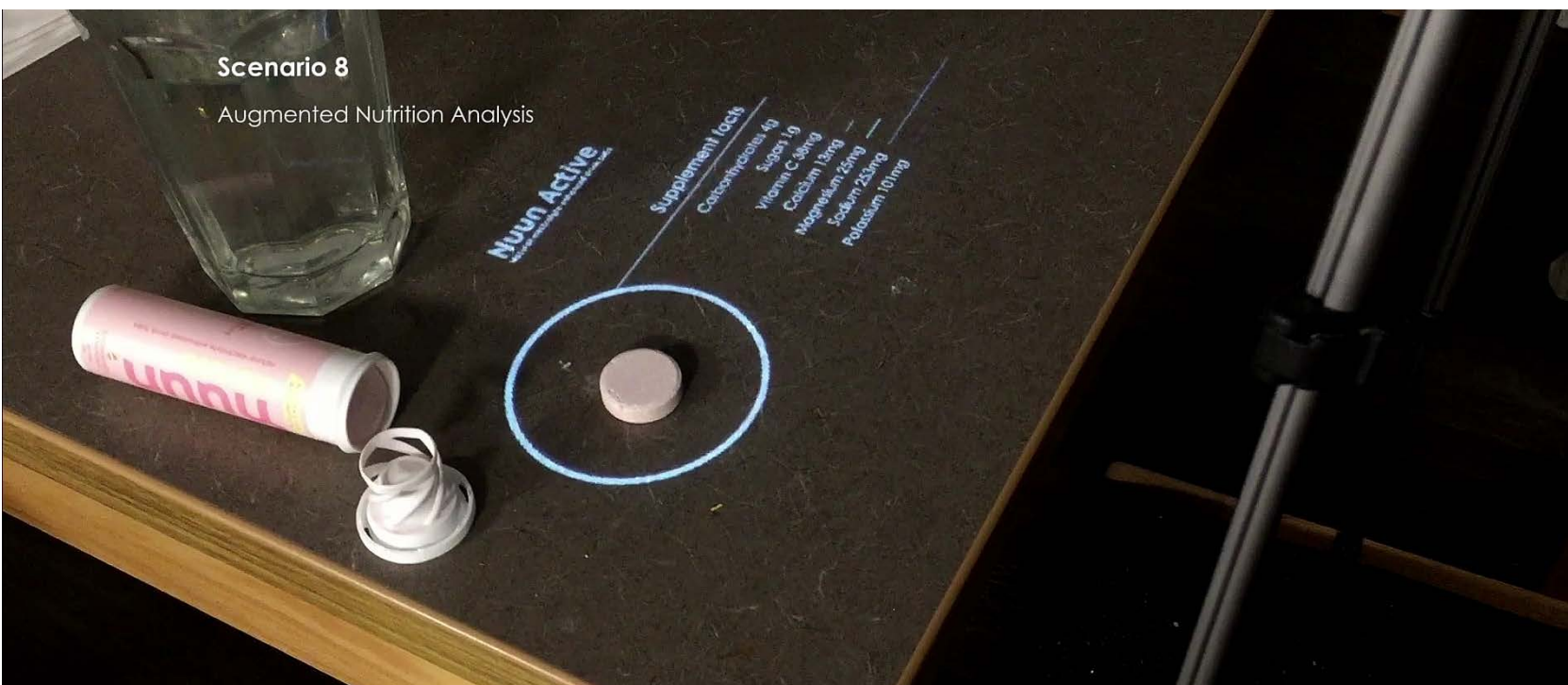
**Scenario 8:  
Augmented interaction for nutrition information**



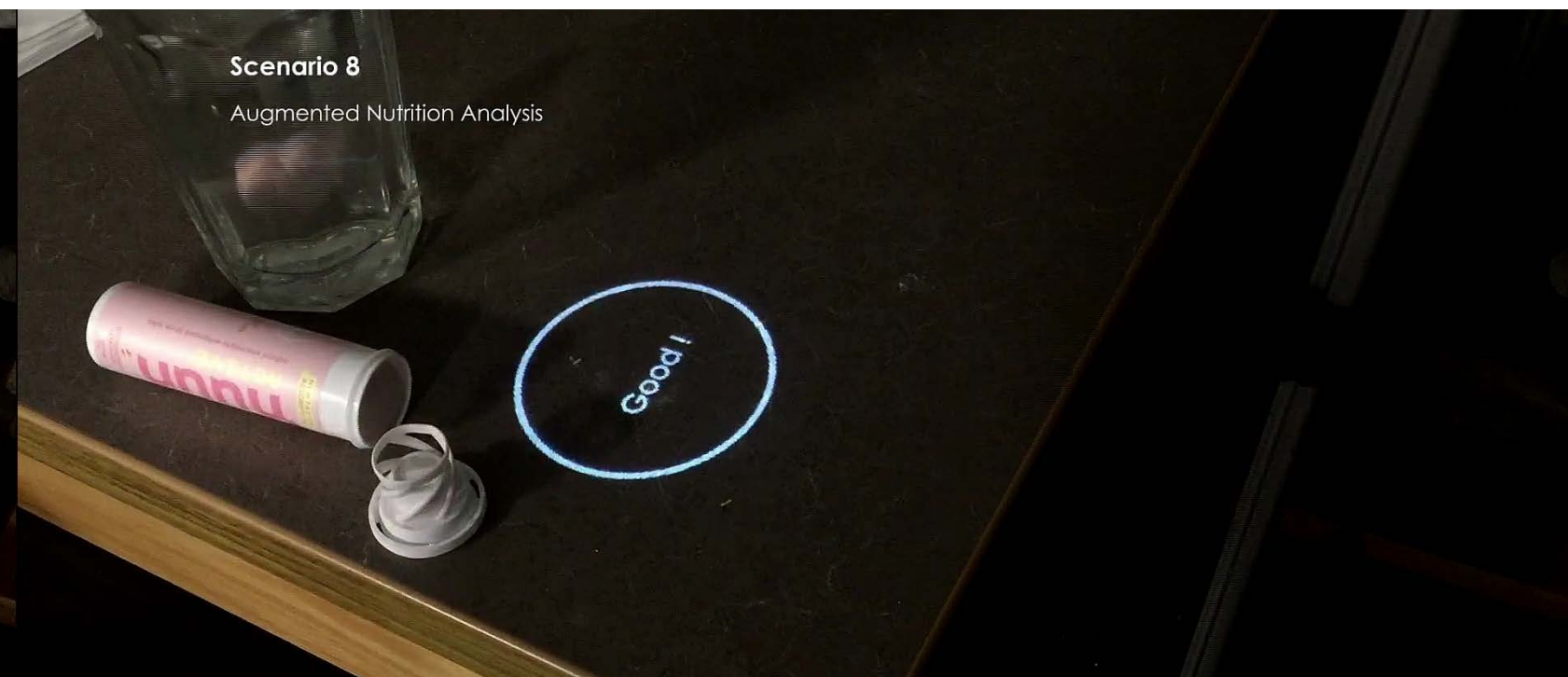
**Figure 73 - 1:** Prior to drinking vitamin water, put a hydration tablet on the surface. And then the table starts to recognize it



**Figure 73 - 3:** Simultaneously GUI recommends user to have a drink of vitamin water, based on user's nutrition status



**Figure 73 - 2:** Table interactively displays the nutrition facts of a tablet



**Figure 73 - 4:** User thus decides to have a drink of vitamin water, picks up the tablet and put it into a cup of water. At the moment of picking up the tablet, table's GUI reacts in reciprocally responding user's action, like displaying "good!" to user's following GUI's recommendation

## Activity Insights

### Communicative GUI

As seen from most of the exercises in this chapter, I intended a situation where virtual GUI exists as an actual element within the environment, interacting with physical objects. With the concept of responding to user's motion or objects, I experimentally attempted for visual interaction to communicate with users as an intelligent being reactive to users' actions. For instance, in Scenario 8, I thought of the user scenario that GUI provides not only information like nutrition status of the product by scanning, but also reciprocally communicates with the user by recommending to do the following action beneficial to him. In terms of communication with the user in real life, I felt through this exercise that more information would become augmented, and its interactivity would be strengthened with more interactivity in the future so it actively communicates with users based on their databases.

### Flexible compatibility between different platforms

In addition to the usability of clicking GUI on a surface, in this chapter, I attempted to think of different types of usability, like collaborating physical actions with augmented GUI. For example, in Scenario 4, I set up a situation where the user transmits text from a smartphone to a surface by doing a physical motion of sending it over. From the perspective of augmented reality, considering flexible compatibility with the other platform was also an insight for expanding the usability augmented GUI contains.

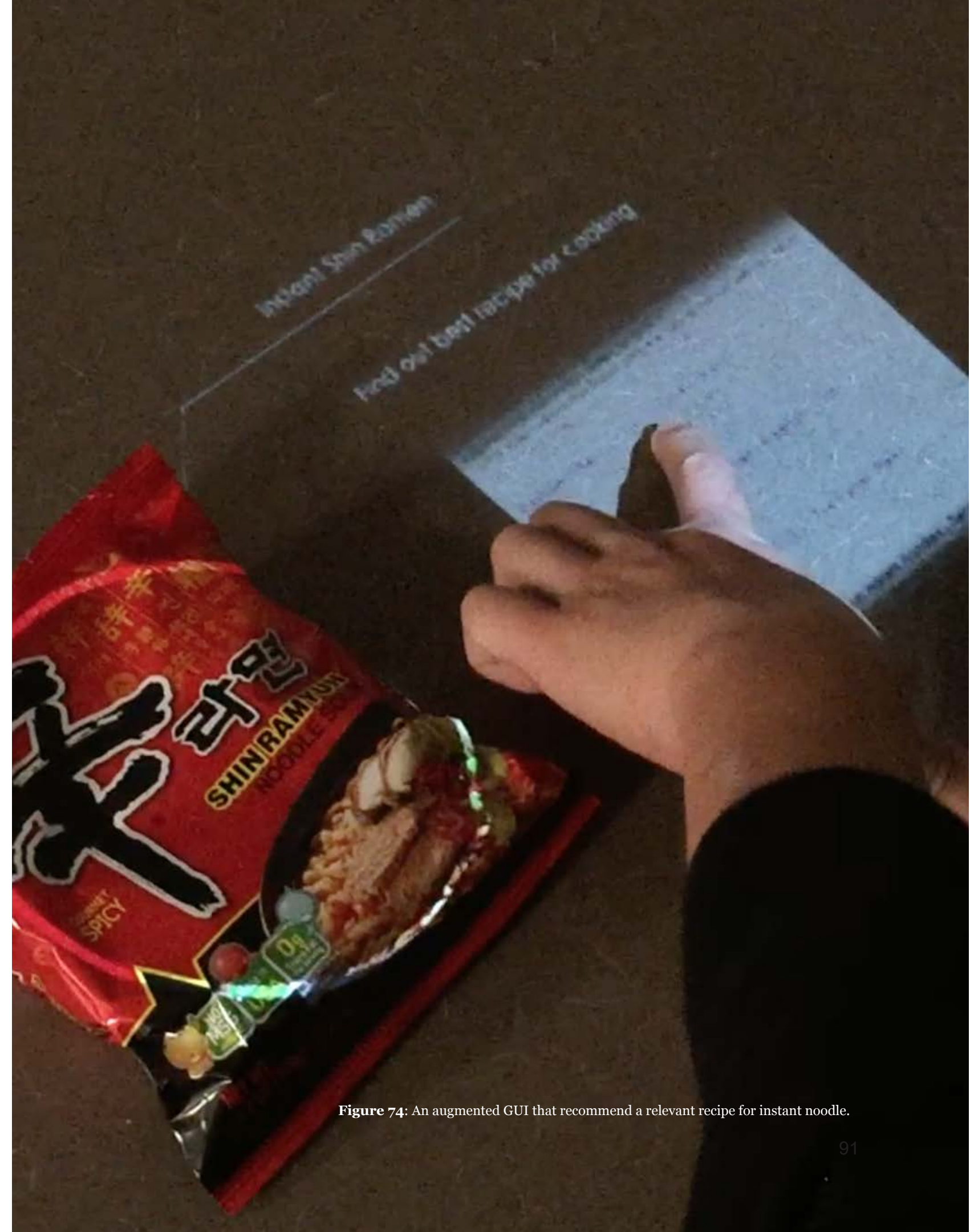


Figure 74: An augmented GUI that recommend a relevant recipe for instant noodle.

## Chapter 7. Developing product model combining with augmented GUI

### Prototyping the GUI usability

As an expansion in designing augmented GUI, in this chapter, I promoted a small group session in order to observe usability by how participants interact with augmented GUI embedded with sensors and movable, fluid graphic motions. Dissimilar to this, the graphic interaction I built in Chapter 7 was a simulative prototype not responsive to actual haptic gesture; this chapter's thesis model was aimed to prototype the interactive surface actually reactive to user's physical communication upon it. In terms of testing out its graphic interaction, this usability test with an actual thesis model indicated the actual user response of how augmented GUI interplays with users under physical environments.

In particular, when it comes to combining playful, reactive interaction with information, participants showed different usability, and this consequently gave me a clue to how degrees of interaction should be applied in an appropriate way, without distracting users from recognizing information they need. In other words, depending on a certain site specificity or situational specificity where the augmented GUI of the product model is going to be, information entailing graphic interaction could influence users' degrees of understanding. For instance, interaction would be highly interruptive when the user is in a situation of urgently verifying the information right on the verge of going out or cooking right beside of it. Like we saw in **Chapter 4**'s informative tendency, Participant 4 showed (checking weather forecast right before going out) a balance between interaction and information was considered crucial in this chapter.

**Figure 75:** A scene that participants play with interactive surface in dark environment.

## Synchronizing GUI with a physical grid

As mentioned above, synchronizing augmented GUI with a physical element is treated as a main goal in terms of fabricating the product model that actually interacts with people and an ambient environment. In envisioning how the information is effectively synchronized with physical surface, I figured out the concept of a grid system for organizing and arraying information. Similar to the theory of a Web design's grid system, in designing an information structure, I thought that utilizing a grid system would enhance the informative unity and consistency for users to understand its relational hierarchy and sequence between each information.

Prior to making an actual product model, I speculatively rendered two different versions of interactive surface-based tables and built rapid mock-ups.

### Direction 1



Figure 76: Honeycomb-shaped interactive surface.



Figure 77: The process of making a mock-up for Direction 1.

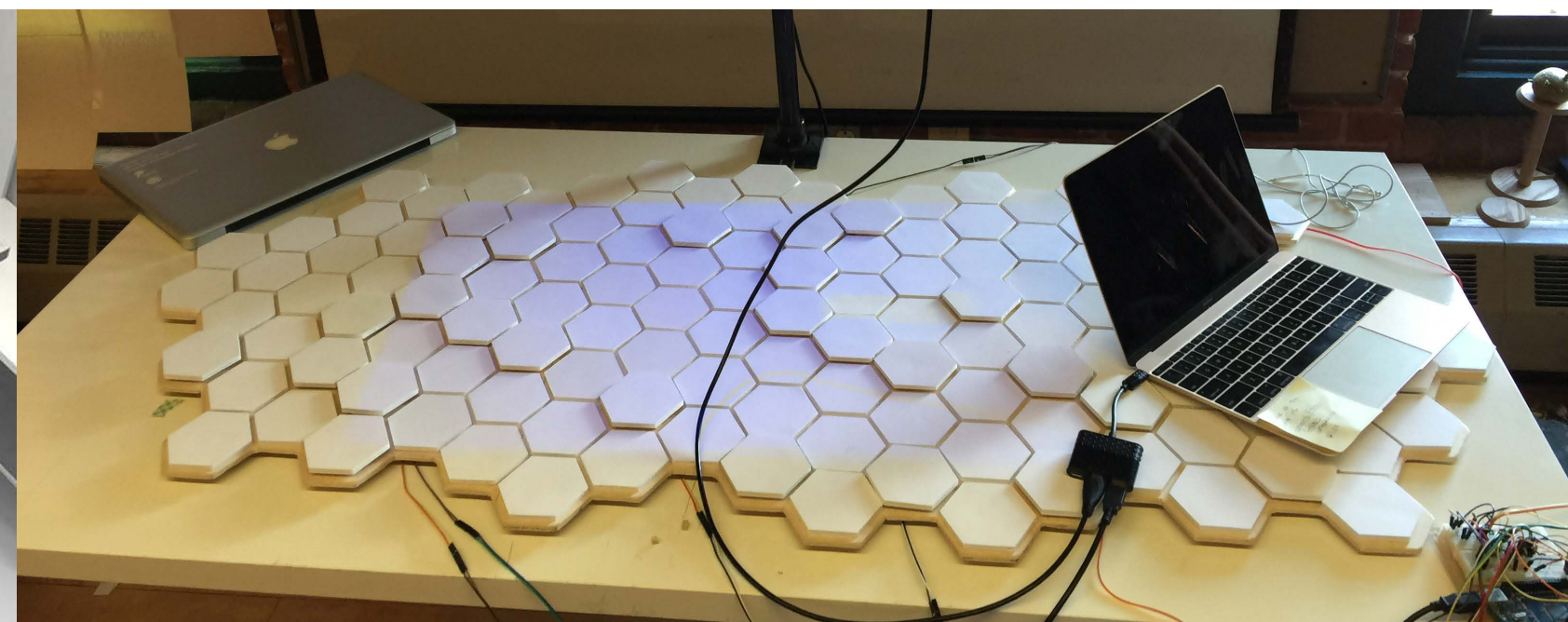
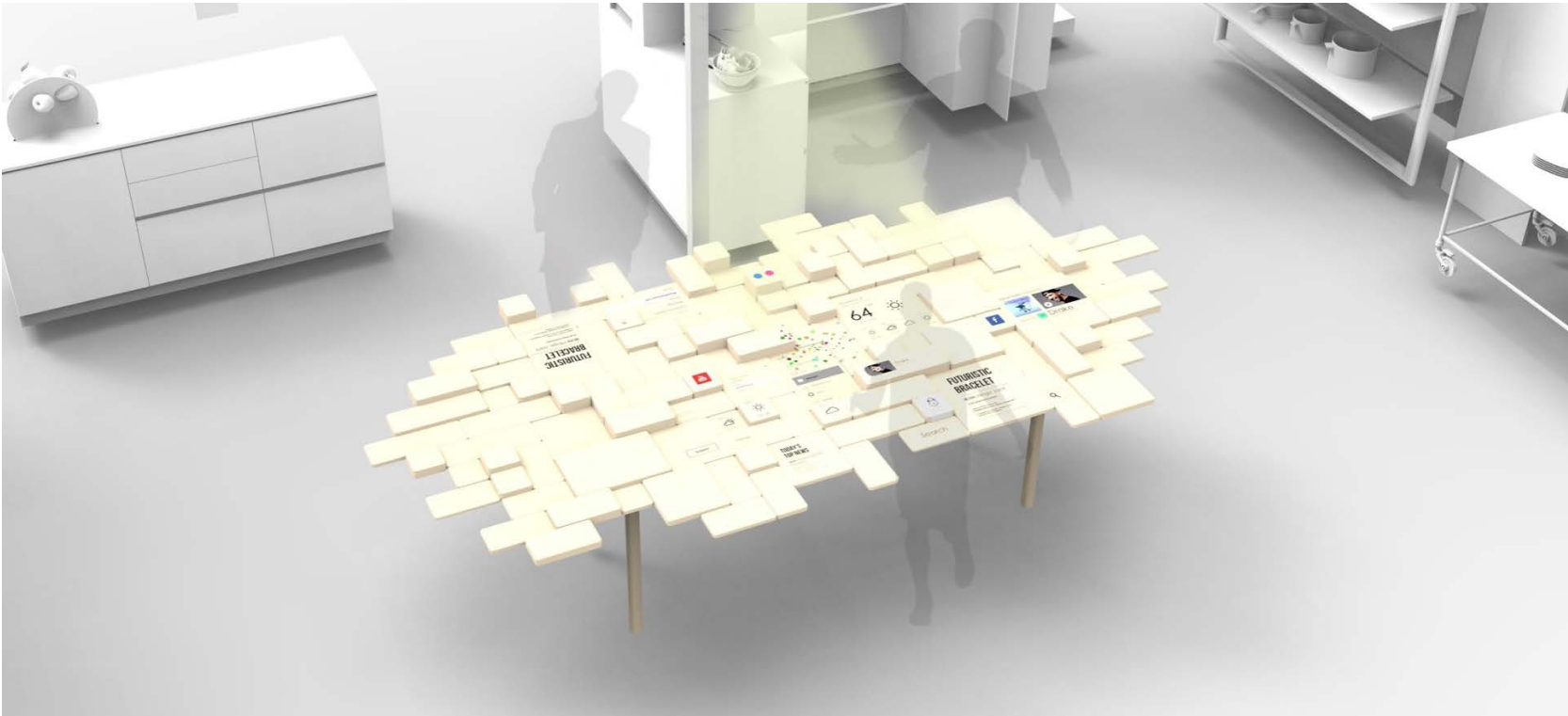


Figure 78: A preparation for fast prototyping with simple projection mapping.

**Direction 1** was an initial strategy for displaying GUIs on a platform that consisted of uniformed grids. To explain the intention, every information is designed and arrayed regularly according to hexagonal grids, and its entailed interaction activates in responding to users' tactile gestures (pressing the grid where the sensor is concealed).



## Direction 2



**Figure 79:** An interactive surface comprises different shapes, sizes, and heights of grids.



**Figure 80:** A mock-up for Direction 2

Dissimilar to **Direction 1**'s hexagonal grid, for **Direction 2**, I attempted to make a difference in the size, shape, and height of the grids. In perceiving augmented information designed in various types, physically diversifying and visualizing the forms of GUI was the main intention. Unlike **Direction 1**'s uniformed informative structure, in **Direction 2**, the user verifies the diverse types and sizes of information (e.g., from simple GUI like weather forecast to Internet news) eligibly fitted in with the size of grids. Moreover, by differentiating each height of the grids, the user perceives an informative hierarchy among ambient information in a physically augmented way. If some grids' heights are higher than others, it means that the information they contain should be treated as a prioritized one among the other information.

### Concept Critique & Direction Decision

On deciding a direction for designing an interactive surface that suitably interplays with the user, I shared lots of ideas and feedback with thesis advisors and people interested in what I was doing. Particularly for the method of arraying information and constructing information structure, the majority of people I met commented similar opinions. These were that **Direction 2**'s various forms of grids could rather hinder the user's attention on information, especially at a certain moment like quickly checking the weather forecast or schedule right before doing something. For perceiving information in real life, they expressed concerns that excessive information via virtual and physical elements happen at one time on the surface. In terms of actual usability, the grid needed to be fixed in a way that was more simplified, and the GUI structure needed to be more clarified and uniformed in order for the user to easily recognize it.

Given advisors and people's advice, I have come to decide to refine and reinforce **Direction 1**'s strategy. With maintaining the concept of a honeycomb-shaped grid as a main platform for containing GUIs, clarifying the informative sequence and structure combined with graphic interaction was continuously considered while developing the thesis model.

## Building thesis model: Reactive GUI via projection mapping

In this chapter, to build an interactive GUI reactive to users' haptic motions onto a physical surface, two major methods were utilized for actualizing it: 1) Processing; and 2) Projection Mapping.

### 1. Processing

Processing is the programming software aimed for visual arts. This tool is highly optimized for graphic interactions, and its compatibility is so flexible for designers to collaborate the coding with external devices or platforms like Arduino, Leap Motion, and Kinect.

### 2. Projection Mapping

In general, Projection Mapping is the technological method for projecting graphics onto a surface, showing interactive visualization between movable graphics and physical objects. In this thesis project, this technique will be utilized in a way of not just projecting the graphics, but also visually responding to users' haptic stimuli.

## General preparation process for thesis prototyping

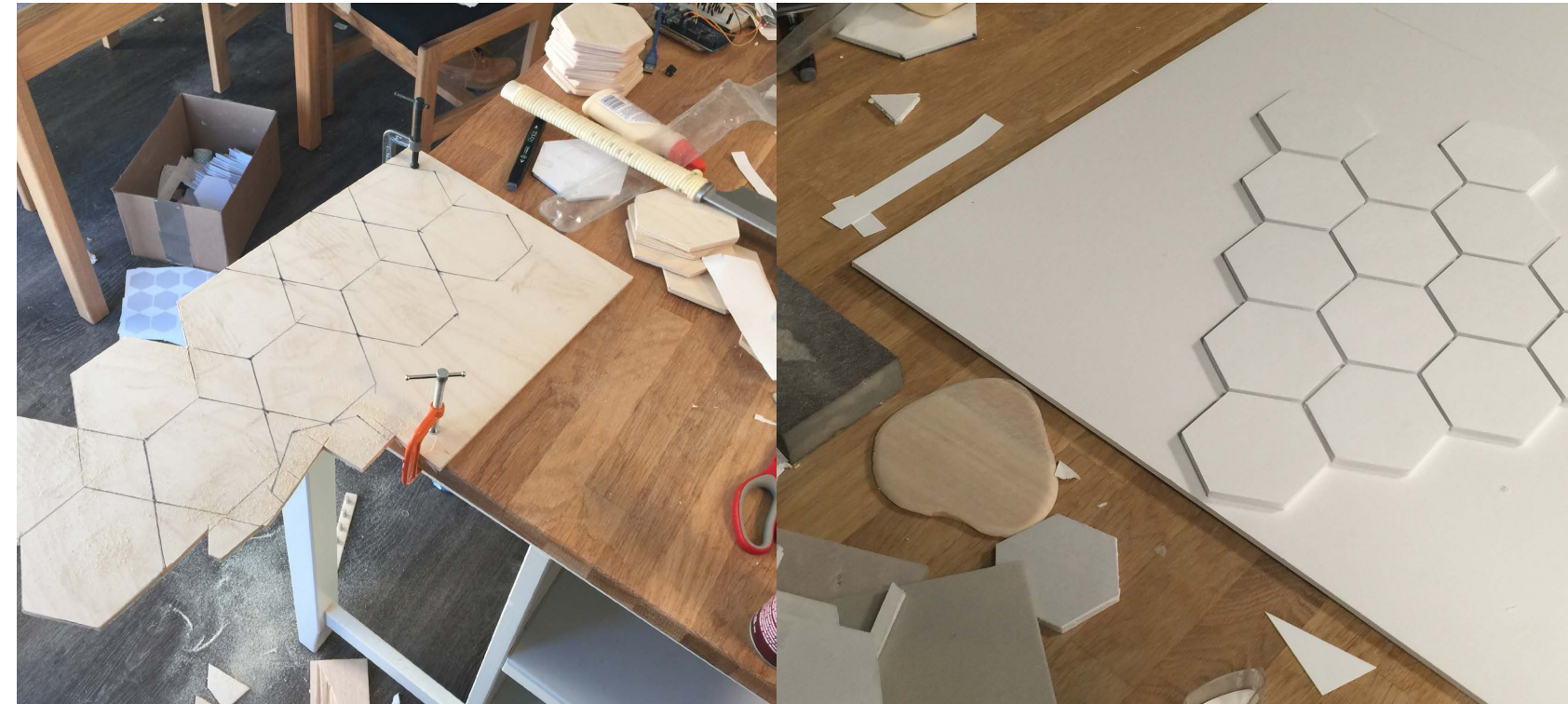


Figure 81 - 2: A process of making a mock up for prototyping(sensor is yet to be embedded).



Figure 81 - 1: To perpendicularly project the GUIs onto a surface, I attached a small sized projector to a frame I modified.

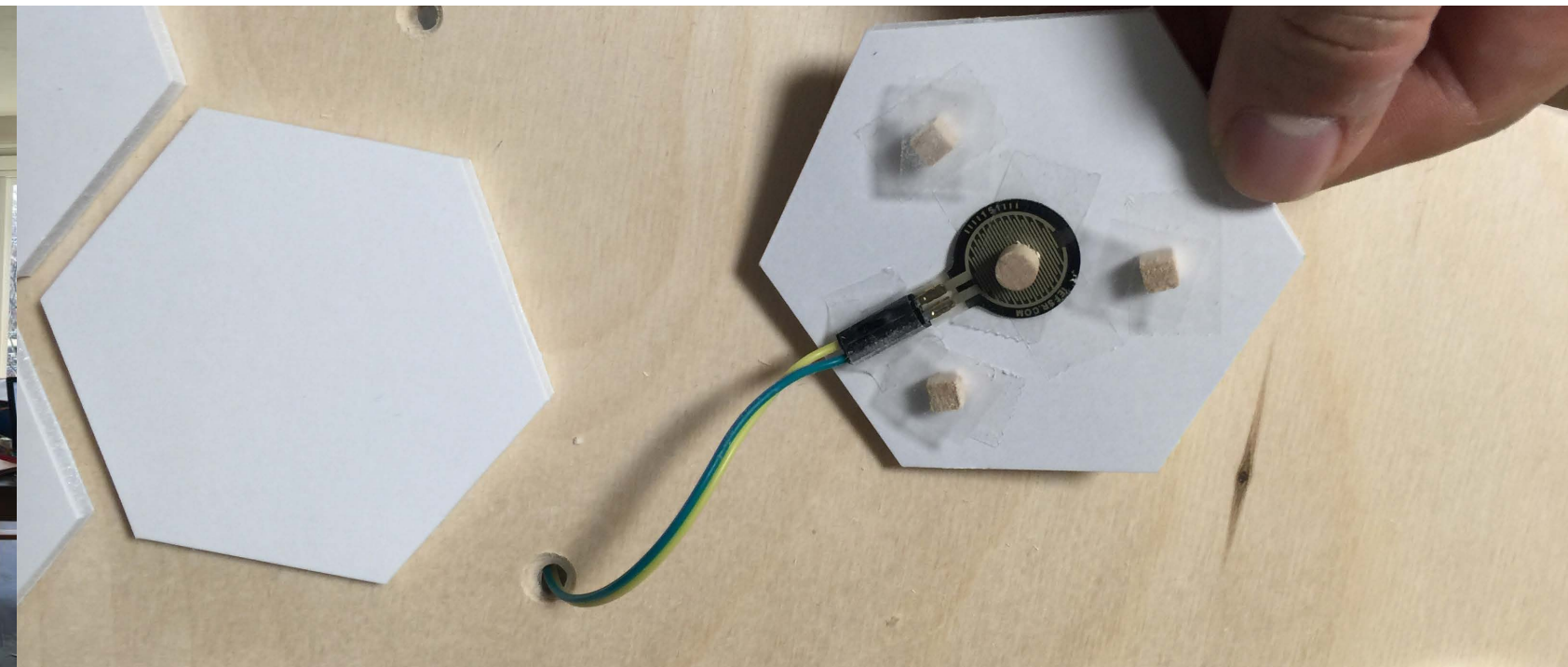
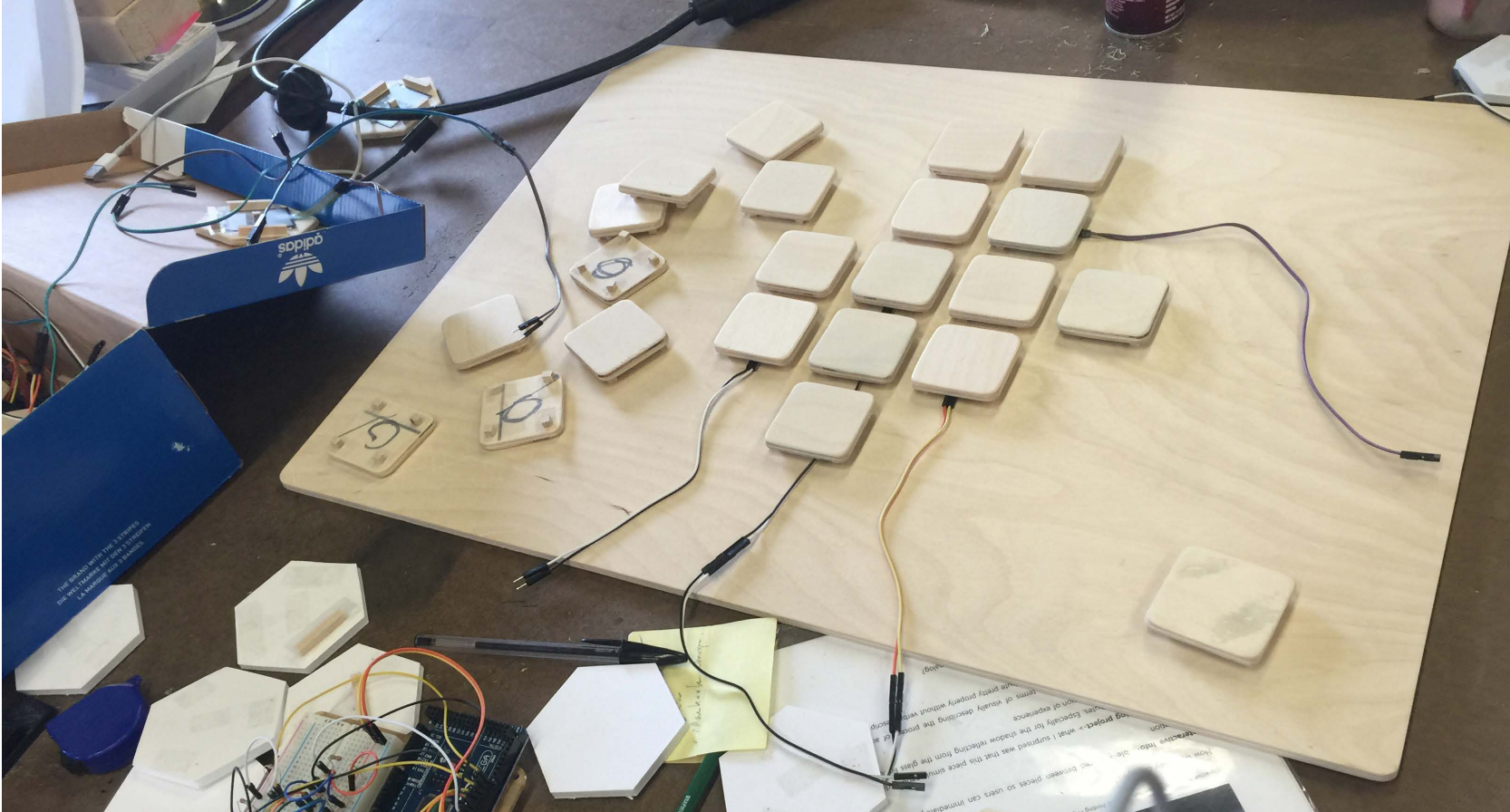


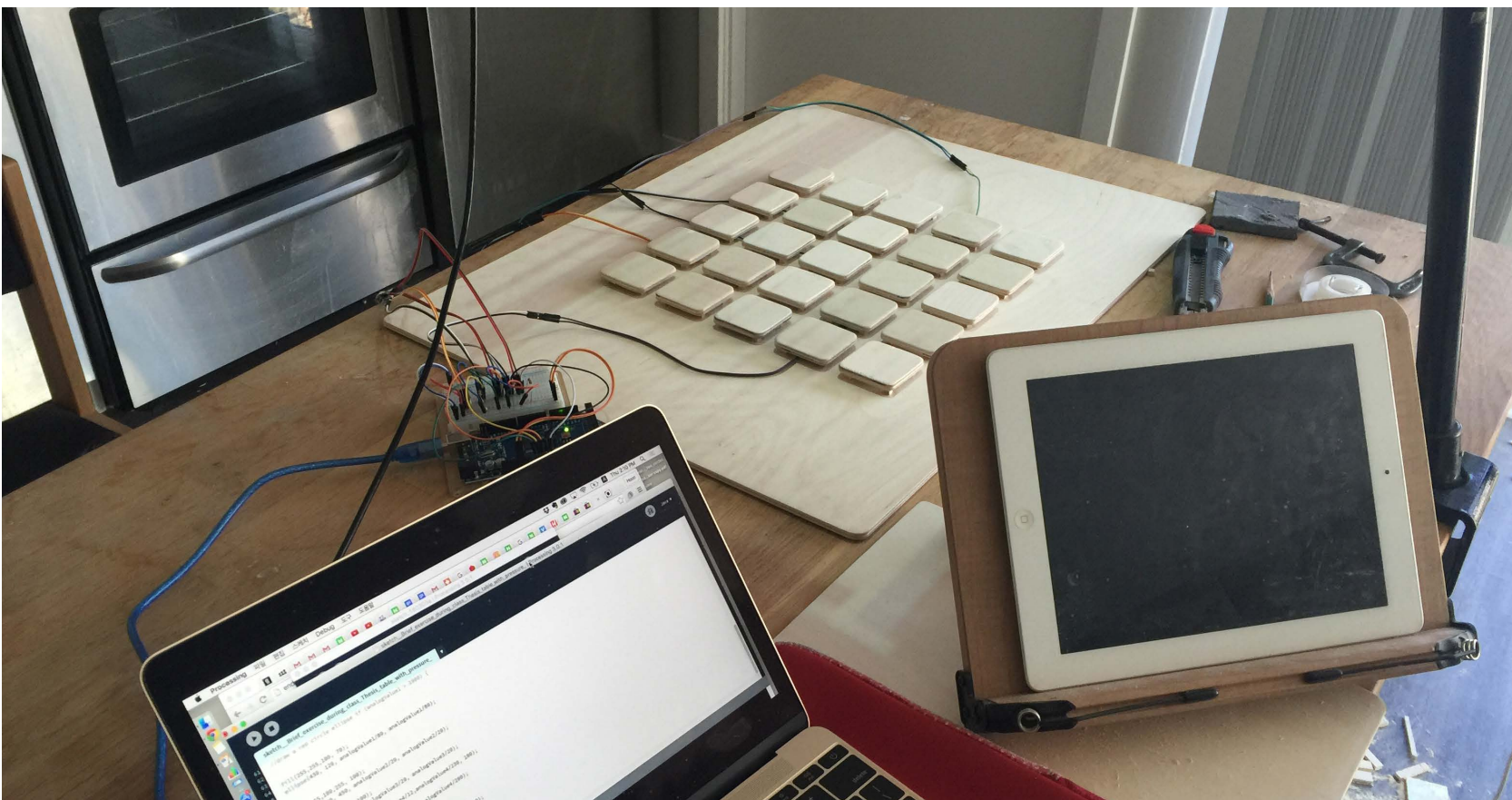
Figure 81 - 3: To generate reactive graphic interactions on a surface, I concealed pressure sensors under the each grids. This sensor will play a role of reading user's haptic stimulus and transmitting it to the computer.



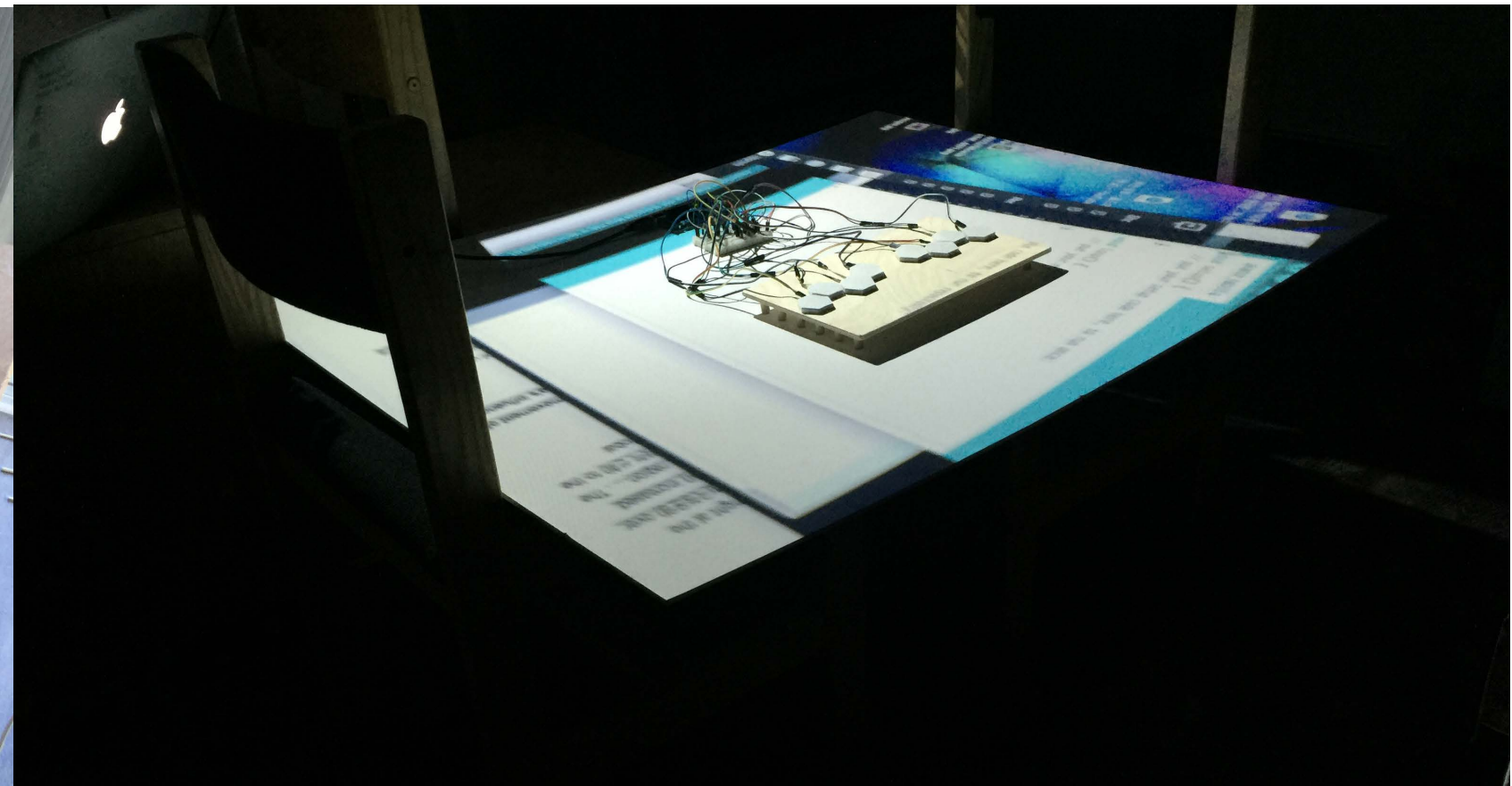
**Figure 81 - 4:** I continuously attached pressure sensors under the wood panel, connected each sensors to an Arduino's breadboard.



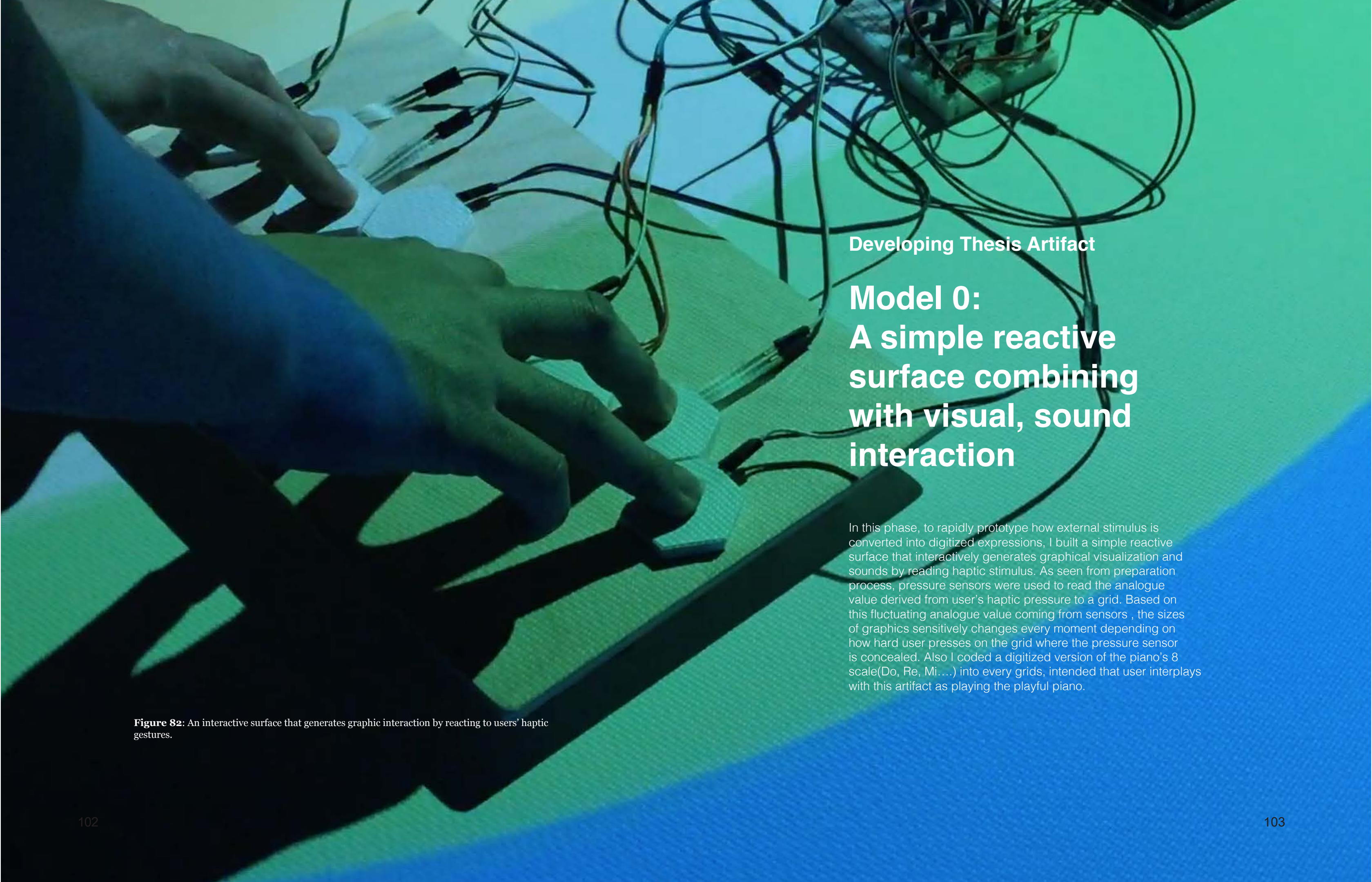
**Figure 81 - 6:** This is the moment of simultaneously re-adjusting the coordinate of GUIs while projecting it on a surface. To easily synchronize the graphic interaction with physical grids, I marked the sensor's position as above by using post-it notes.



**Figure 81 - 5:** After setting the grids in align, I verified that coding is functionally appropriate to synchronize with external objects.



**Figure 81 - 7:** After synchronizing coordinates with grids, I started to adjust projector's resolution and check the coding is workable prior to implementing projection mapping.

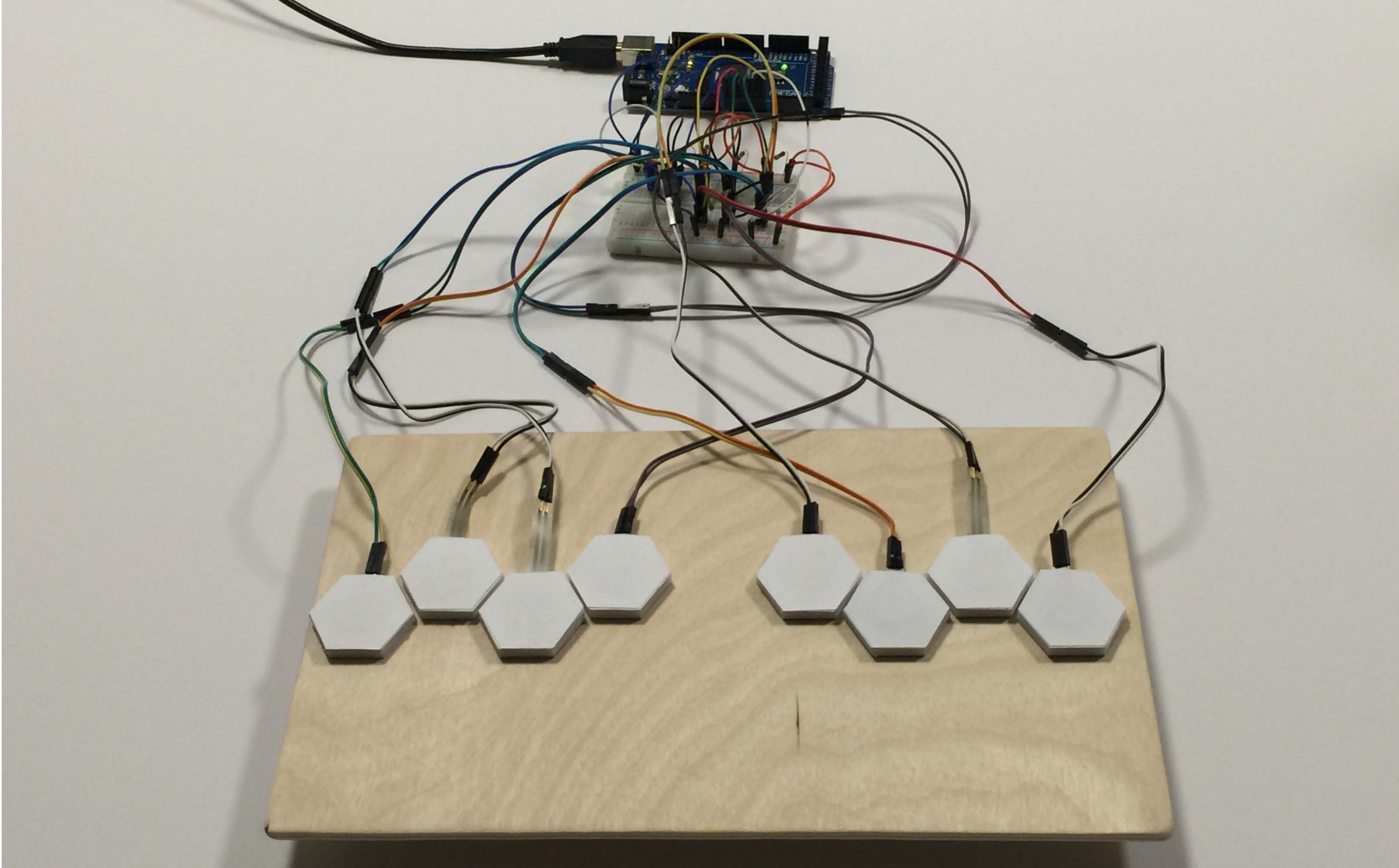


## Developing Thesis Artifact

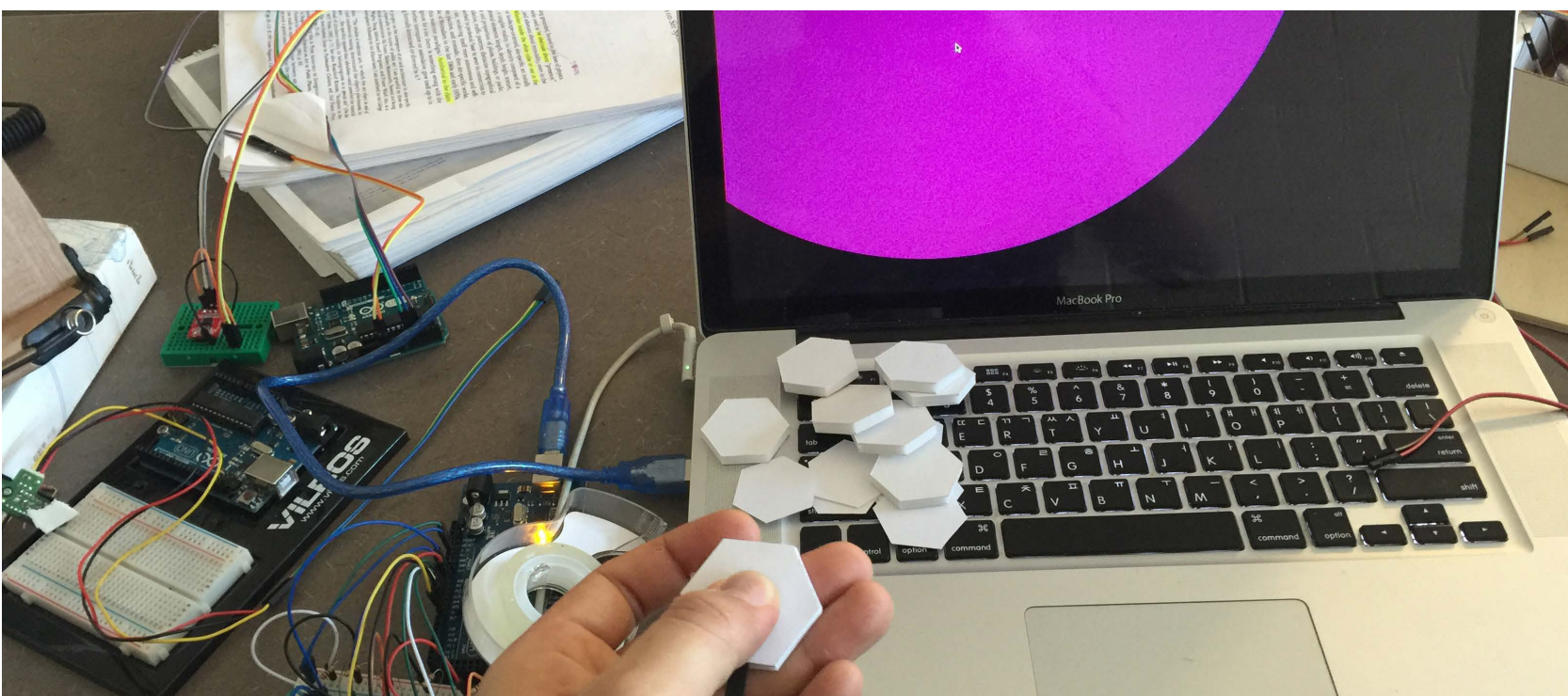
### **Model 0: A simple reactive surface combining with visual, sound interaction**

In this phase, to rapidly prototype how external stimulus is converted into digitized expressions, I built a simple reactive surface that interactively generates graphical visualization and sounds by reading haptic stimulus. As seen from preparation process, pressure sensors were used to read the analogue value derived from user's haptic pressure to a grid. Based on this fluctuating analogue value coming from sensors, the sizes of graphics sensitively changes every moment depending on how hard user presses on the grid where the pressure sensor is concealed. Also I coded a digitized version of the piano's 8 scale(Do, Re, Mi...) into every grids, intended that user interplays with this artifact as playing the playful piano.

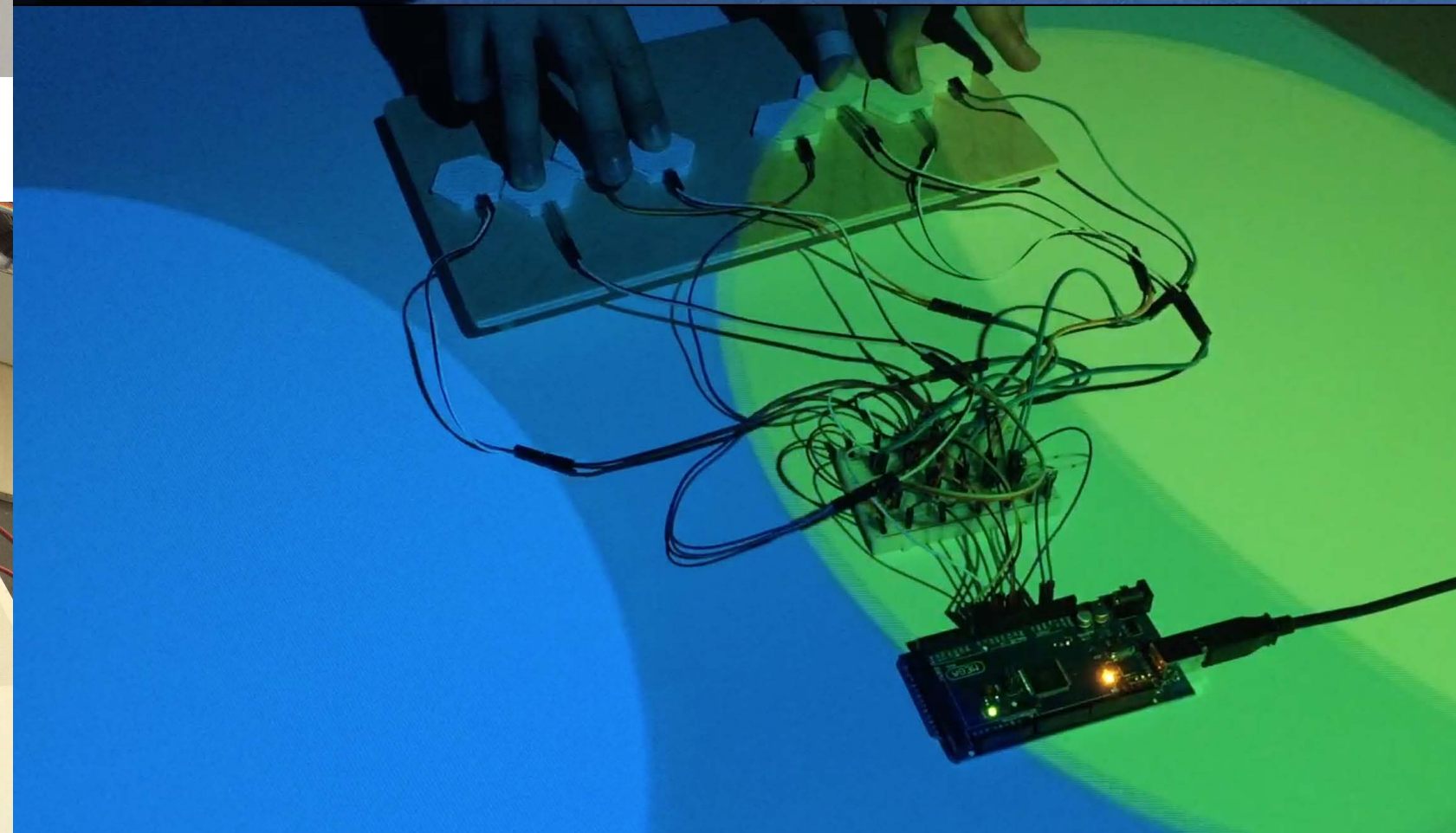
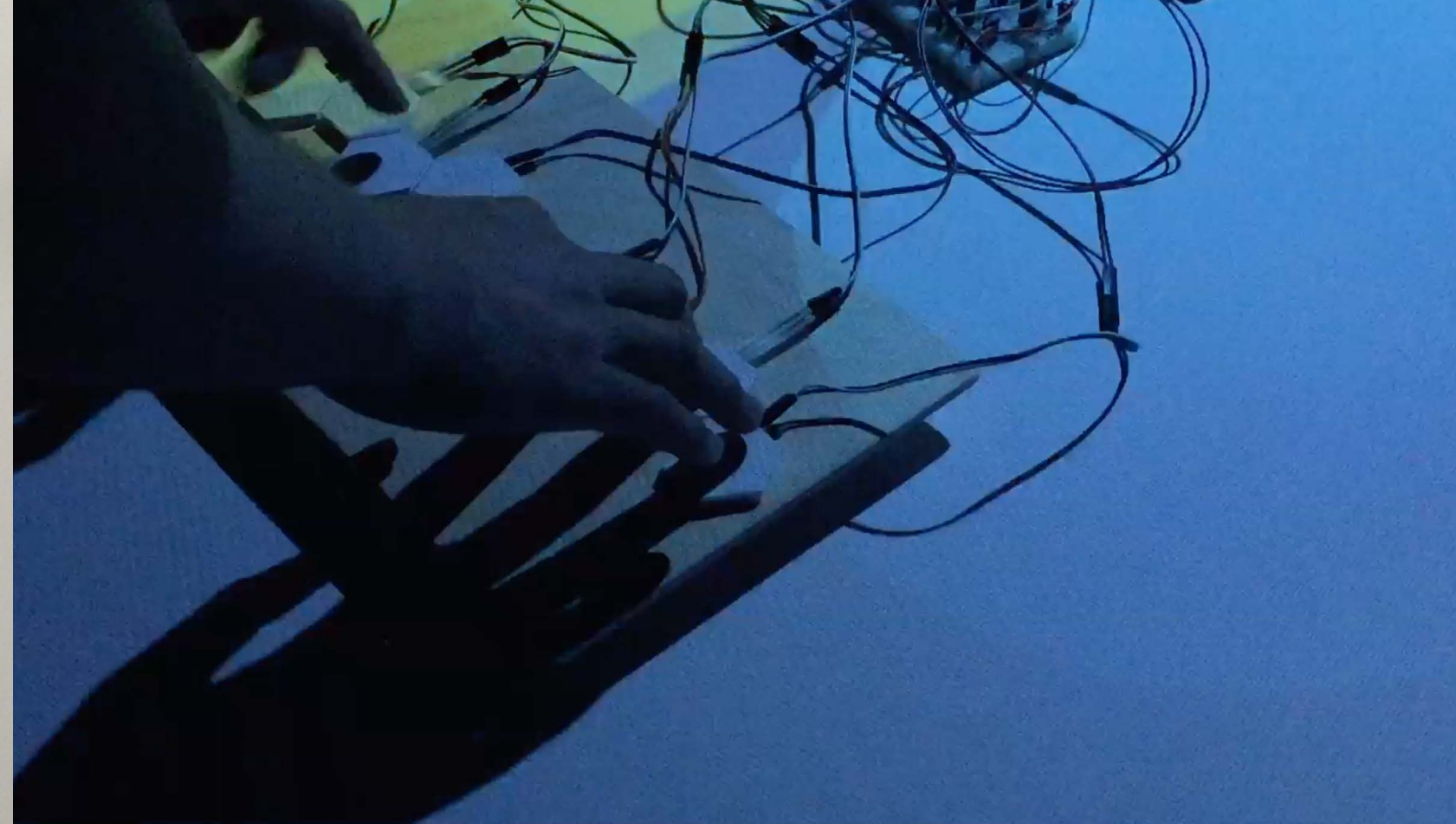
**Figure 82:** An interactive surface that generates graphic interaction by reacting to users' haptic gestures.




**Figure 83:** An image of thesis artifact model o



**Figure 84:** A footage of testing the sensibility of a pressure sensor. Depending on physical pressure, the size of a circle reactively changes.



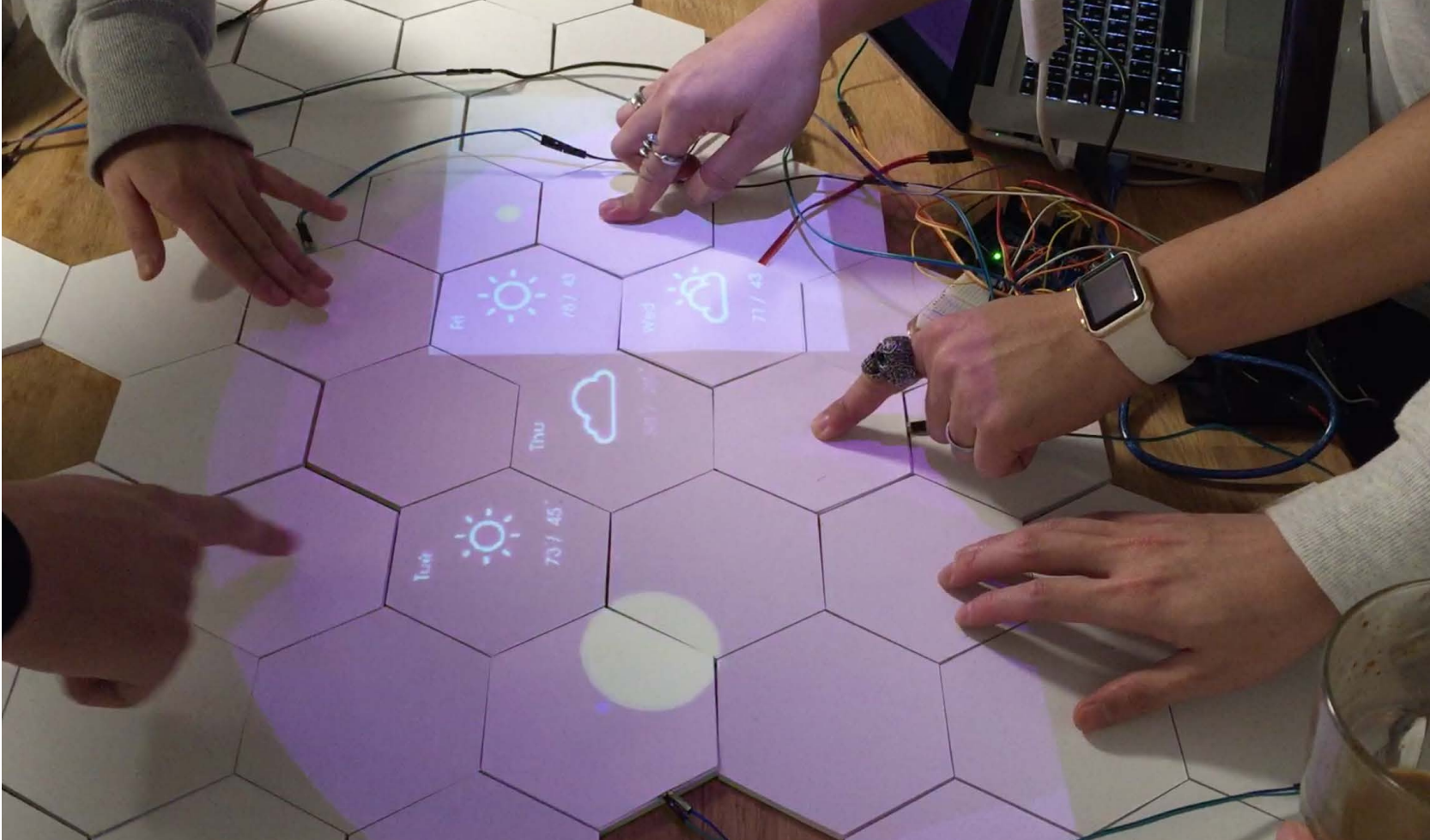
**Figure 85:** A footage of interacting with thesis artifact. As mentioned, I intended that graphic reacts to user's haptic stimuli, and the sound is simultaneously generated through it like playing the interactive piano.



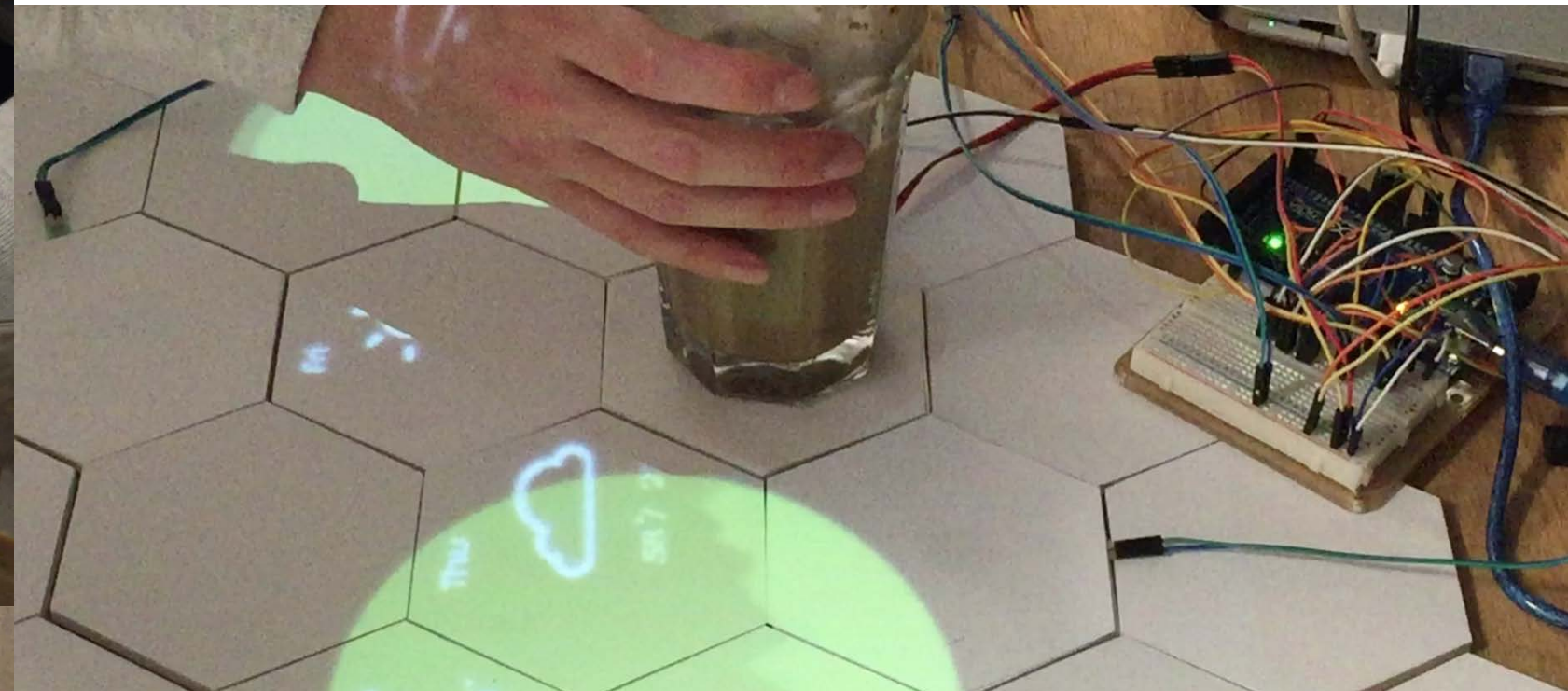
## Model 1: Combining graphic interactions with information GUI

Based on **Model 0**'s experience, in this phase, I started to integrate information structures with reactive, movable graphic interactions. To test out usability, I invited several participants and gave them an imaginary situation of playing with graphic interactions while verifying the weather forecast on a surface. Similar to **Model 0**'s usability, participants were given the situation of playing with the augmented graphic interactions, like manipulating the size of graphical figures, while verifying weather information. In this test, particularly what is considered important was that the graphic interaction is beginning to be perceived to be an augmented, realistic element that interacts with the user's gesture. By synchronizing the graphic interaction's coordinates with the position of sensors, its usability for interacting with augmented graphics was enhanced in a more immersive way (For example, through this kind of synchronization, it shows that the user makes or manipulates a virtual circle from his hands in an actual environment by pressing or touching the surface).

**Figure 86:** An usability test about interacting with augmented graphic interaction that co-exists with information



**Figure 87:** A footage of playing with augmented graphic interaction by pressing the grid where the sensor is concealed.



**Figure 88:** To see how sensitive the thermo sensor is and how thermo sensor affects graphic interaction, I attached it under the grid, and then attempted to put a cold object over its surface. However different to what I expected, the numerical flow of analogue value it transmits was extremely unstable so the graphic interaction that receives its value was not functioned properly.



**Figure 89:** Based on the idea that interaction is activated by user's approach, I attempted to set up the IR sensor under the surface to read user's reach. Different to Figure 95's thermo sensor, IR sensor's value flow was relatively stable, but the sensor frequently generated irregular, uncontrollable interactions. Because of that, it is still required to being eased down especially when people get close to it.

## Model 2-1: Designing the information structure for augmented scheduler GUI

In this phase, I started to focus on building a collective information structure aimed to be interactive with actual environments and users' situational specificities. In considering a speculative user scenario for this GUI surface, I set up a situation of verifying or manipulating information like weather, schedule, and music GUI while on the verge of doing other actions. So given the framed circumstance, in order to make users quickly access and recognize the information they need, individual information was designed to be simplified into pictogram-based things. (Regarding this approach, we already saw the experiment's participants' informative tendency in **Chapter 4**. That is, related to their situational specificities, like needs for checking information right before the next action, they showed that they wanted to be provided a very brief version of information or notification not disruptive to their actions.) From the perspective of informative affordance, contextually simplifying and clarifying its contents and hierarchy was treated as important throughout this phase in relation to users' situational specificities.

**Figure 90:** An information structure of scheduler GUI that combines with aligned grids.





**Figure 91:** A brief usability test about information structure of GUI



**Figure 92:** A footage of verifying information in information structure. For example, when user clicks the today's weather forecast, it simultaneously provides the entailed informations like date, schedule.

## Model 2-2: Expanding the Adaptability of Interactive Surface in an Actual Environment

In a sense expanding the informative structure that the thesis models have been showing, in this phase, the overall structure of the interactive surface was relatively enlarged, and its contents were relatively more diversified in terms of usability in an actual environment. Similar to the overall direction points of simplifying information, in this exercise, I also intended to map out simplified, pictogram-based information to the surface. Except some contents for notification that requires a bit of detailed information like news or schedules, most of the information is minimalized, and its affordance is clarified by emphasizing symbol texts. (To explain, in order to make people recognize its functional attributes, I intentionally utilized emphasized, minimalistic typography instead of graphical pictogram icons.)

Considering users' informative tendencies in real life. I have come to feel that the concept of integrating typography to the structure was efficient in the sense of clarifying the contextual message of information. Also, in terms of communicating with users in real life, I was led to think of some notion that experimentally combines with the other expression methods should be aimed to sustain the proper level of informative affordance.



Figure 93: The overall informative structure of model 2-2's surface

## Reactive graphic interaction at the user's haptic motion

In interacting with augmented GUI on the surface, similar to the previous work's direction, I considered the usability point that users interplay with playful interaction while verifying and manipulating information. By the pressure sensor attached under the grid, the surface can read haptic motion and translate it into reactive, movable graphic objects.

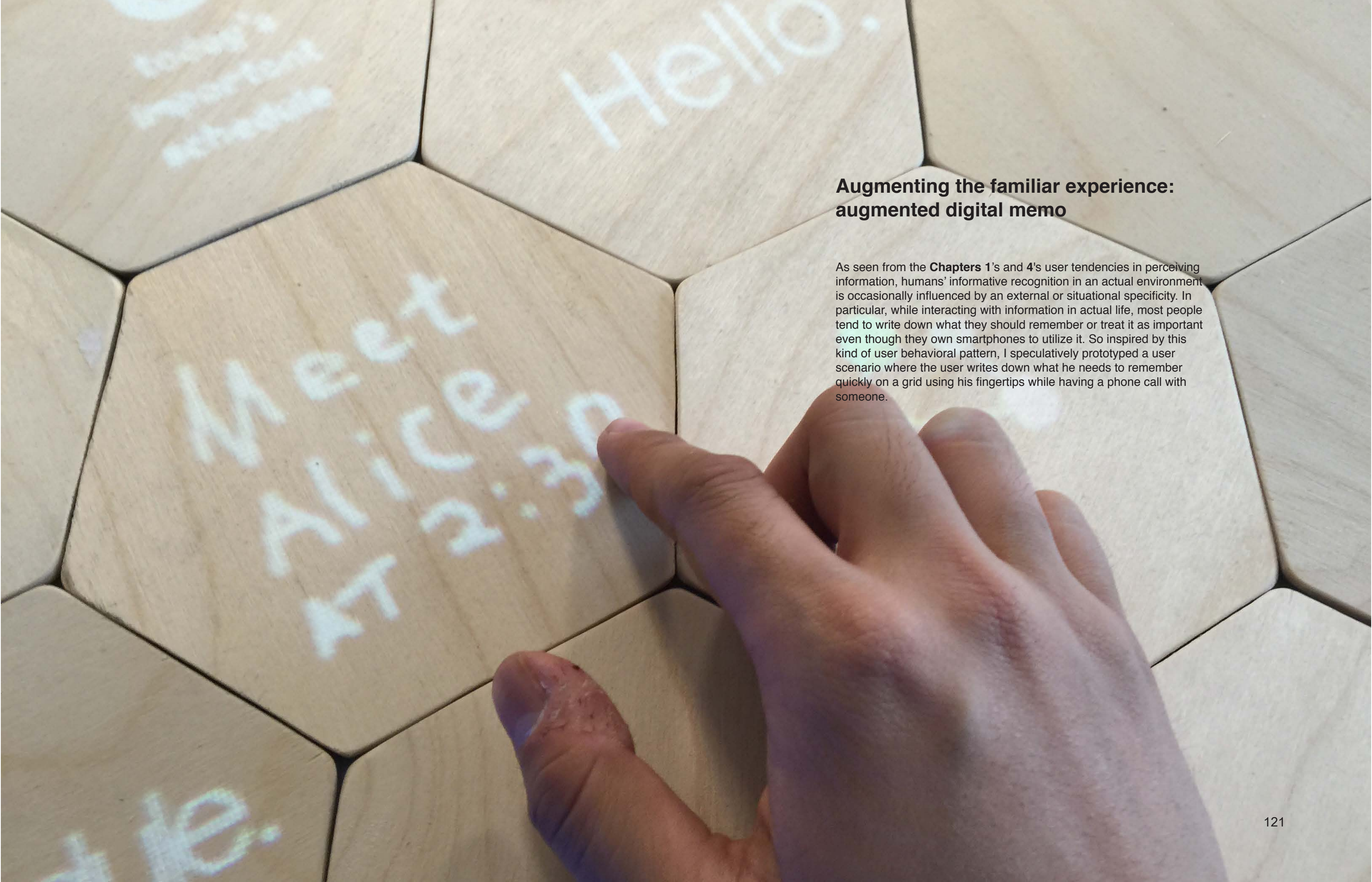
**Figure 94:** A moment of playing graphic interactions: Virtually touching the graphics reactive to user's haptic motion.

## Augmented interaction beyond the surface

As an extension of the augmented indicator concept prototyped from Chapter 6's Scenario 8, in this phase I thought of an user-scenario that the surface augmentedly interacts with a physical objects not only via surface itself, but also projecting UI(User Interface) to the object 's surface. In experiencing augmented information via mediums in actual environment, I attempted to expand the usability in that user perceives the GUI that co-exists between different types of physical mediums virtually connected each other.



**Figure 95:** By utilizing an another projector that ables to project an additional image from the other angle, I prototyped this scene that the surface augmentedly recognizes the object, displays its status. For example, the GUI on the object displays how degree of content is left in the object, while the another GUI on the surface displays its nutrition facts.



**Augmenting the familiar experience:  
augmented digital memo**

As seen from the **Chapters 1's** and **4's** user tendencies in perceiving information, humans' informative recognition in an actual environment is occasionally influenced by an external or situational specificity. In particular, while interacting with information in actual life, most people tend to write down what they should remember or treat it as important even though they own smartphones to utilize it. So inspired by this kind of user behavioral pattern, I speculatively prototyped a user scenario where the user writes down what he needs to remember quickly on a grid using his fingertips while having a phone call with someone.

## Thesis model insights

### A hybrid experience between virtual and physical experience

This is a scene where users virtually generate a cluster of circles on an augmented grid surface while interacting with GUIs. Still, there are lots of ways of diversifying UX scenarios for designing the experience of graphical interaction, but in this exercise, I continuously focused on utilizing pressure sensors as a crucial medium in a certain meaning. Converting physical motion into digitized data by sensors, from an experiential viewpoint, it interacts with users in a form of hybrid experience, which is distinctive to virtual reality's experience: Interacting with virtual data in a physical communication method. In a sense integrating between physical and digital experience, data-visualization combined with AR (Augmented Reality) technology involves the possibility of experiential expansion. With this kind of technological attempt, I believe that it will lead to suggest a new, unexplored hybrid experience on an interactive medium.

**Figure 97:** A scene that user plays with augmented graphic interaction by touching the grid where the sensor is embedded.

## Conclusion

These days, more and more things are interactive and being extended to the physical environment. Developed from the original attribute of providing functionality, contemporary digital interaction is showing the possibility of communicating with humans as an intellectual, artificial being. It interacts with users via graphic interactions that imitate a living object's attributes and also actively communicates with them as a way of recommending what is beneficial to them, based on their big data or informational tendencies collected from daily life. In essence, its interactivity is becoming more immersive in users' lives by integrating with a user-centered approach.

In this thesis, I tried to expand the possibility of augmented GUI coexisting with physical objects and the environment and interacting with users based upon an understanding of their situational specificities and informational propensities. In perceiving information in an actual environment, constructing the information structure of an augmented GUI was important, considering the terms of informative affordance. Depending on situational specificity, as shown in **Chapter 4**, people showed similar behavioral patterns in perceiving information, and then based on user observations, I have come to build several types of interactive outcomes in **Chapters 6** and **7**. In terms of experimentally prototyping a futuristic scenario, the thesis models I designed for augmented, reactive GUI interactions with the physical environment consequently gave me some insights about actual informative usability.

For the next step of this project, I will develop the information structure of **Chapter 7's Model 2-2** and attempt to refine the graphic interactions the interactive surface's GUI contains. As a theoretical expansion for envisioning and exploring futuristic usability of augmented/reactive GUI, still for me, there are still lots of undiscovered areas.

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