

# Graspable AI: Physical Forms as Explanation Modality for Explainable AI

Maliheh Ghajargar  
Malmö University  
Malmö, Sweden

Jeffrey Bardzell  
Pennsylvania State University  
PA, USA

Alison Smith Renner  
Dataminr  
USA

Kristina Höök  
KTH  
Sweden

Peter Gall Krogh  
Aarhus University  
Denmark

## ABSTRACT

Explainable AI (XAI) seeks to disclose how an AI system arrives at its outcomes. But the nature of the disclosure depends in part on who needs to understand the AI and the available explanation modalities (e.g., verbal and visual). Users' preferences regarding explanation modalities might differ, as some might prefer spoken explanations compared to visual ones. However, we argue for broadening the explanation modalities, to consider also tangible and physical forms. In traditional product design, physical forms have mediated people's interactions with objects; more recently interacting with physical forms has become prominent with IoT and smart devices, such as smart lighting and robotic vacuum cleaners. But how tangible interaction can support AI explanations is not yet well understood.

In this second studio proposal on Graspable AI (GAI) we seek to explore design qualities of physical forms [12] as an explanation modality for XAI. We anticipate that the design qualities of physical forms and their tangible interactivity can not only contribute to the explainability of AI through facilitating dialogue [5], relationships [18] and human empowerment [15], but they can also contribute to critical and reflective discourses on AI [2, 13]. Therefore, this proposal contributes to design agendas that expand explainable AI into tangible modalities, supporting a more diverse range of users in their understanding of how a given AI works and the meanings of its outcomes.

## CCS CONCEPTS

• **Human-centered computing** → **Interactive systems and tools; Interaction design; Interaction design theory, concepts and paradigms;**

## KEYWORDS

Tangible Interaction, Explainable AI, Human-Centered AI

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## 1 FROM XAI TO GAI

Artificial Intelligence (AI) is embodied increasingly in our everyday lives. AI perceives things in the world, categorizes content and makes decisions. From music recommendations to higher-stakes scenarios, such as policy decisions, drone-based warfare, and automated driving directions, AI affects us all. Explainable AI (XAI) explores mechanisms for demonstrating how and why intelligent systems make predictions or perform actions to help people to understand them and feel safe while using these systems [27]. XAI research includes both global explanations (i.e., explaining models as a whole) [4] and local explanations (i.e., explaining—or rationalizing—individual predictions) [22]. Hence, it is crucial to inform people about systems' decision-making processes and also their limitations, rather than just their accuracy or other performance measures. This understanding is especially important in higher-stakes applications, such as policy decisions and in hiring algorithms. It helps to create better relationships by either ensuring AIs are operating without bias or by revealing them. Yet, XAI is not always a perfect solution; trust is particularly hard to calibrate and explanations sometimes result in over- or under-reliance of systems. XAI benefits from designing interactions based not only on user needs and perceptions but also on ways to empower people to grasp the complexities and dynamics of AI systems [15]. XAI relies on available and limited interaction modalities and as a consequence, explanation modalities have so far been predominantly limited to visual, audible, and textual [8]. Our proposal is an attempt to broaden the repertoire of AI explanation modalities, specifically to include tangible and embodied interaction.

Our first Graspable AI (GAI) studio, organized at the ACM Tangible Embodied and Embedded Interaction (TEI) 2021 conference sought to broadly link conversations about tangible and embodied interaction and product semantics to XAI [13]. As a multidisciplinary group, coming from diverse backgrounds of humanities, design and computer science, our point of departure was to understand what kinds of explanations end users need from AI, and what the AI systems can actually explain. We summarized the result of the workshop in three main themes and challenges inherent to AI

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systems that fruitfully may be approached through the notion of “Graspable”: “growth/decay”, “unpredictability” and “intentionality” [14]:

*Graspable growth/decay* is the challenge related to how humans can perceive the changing nature of algorithms over time. The most intuitive form of growth/decay for humans are biological growths and decays. We tend naturally and intuitively to understand when a plant grows new leaves, or loses old leaves or when it dies. *Graspable unpredictability* originates from a perspective that we cannot make all AI systems perfectly predictable, hence XAI can be designed in a way that makes the AI’s unpredictability graspable. But while unpredictability may not be an issue for music recommender systems, its implications in powerful robots used in manufacturing and surgery are more serious. *Graspable intentionality* is perhaps one of those qualities that AI shares with IoT and automated systems. They appear to have their own intentions. Whether or not this is true from a technical perspective, humans often experience them as such, for instance when an algorithmic hiring tool “discriminates”. Taking stock of what we learned from the previous GAI studio and the recent advancements in XAI, in this proposal we will focus on physical interactions with AI as one of the many interaction modalities included in TEI. More specifically since explanatory dialogues happen during interactions, we propose to use the qualities of physical forms as an explanation modality and aim to discuss its potentials and limitations within a diverse community of scholars.

## 2 FORMS AS EXPLANATION MODALITY

Our studio explores whether and how physical forms can be considered as an explanation modality for XAI. To this aim we aim to have a pluralistic view to forms, which includes perspectives from tangible interaction, product semantics, aesthetics, and ecological thinking, as well as attempts to go beyond cognitive perspectives of grasping [23]. Tangible Interaction notably was based on the promises that physical interaction with computers would make them graspable and more understandable for their users. On the other hand, research in a variety of domains such as design, mathematics, semantics and aesthetics confirm that qualities of visual and physical forms (e.g., their shapes, colors, and interactivity) are capable of explaining not only the functionalities of an artifact, but also its meaning and context [20, 21]; emotions [25] and even its wider cultural significance and value [3].

### 2.1 Tangible and Embodied Interaction

Graspable or Tangible User Interfaces (TUI) are a way to grasp and manipulate computing systems by merging digital systems with everyday physical objects and spaces [11, 19]. Over the years the TEI has evolved, and related concepts have emerged: Embodied interaction is concerned with how computing systems and our interaction with them can change our perception of the physical reality [7], a material-centered approach to Interaction Design emphasizes the material manifestations of the interaction and its form-giving processes [28, 31, 32], and somaesthetic design, a body-centred approach to interaction design, offers a holistic and relational approach to interaction design, incorporating the body and its movements into design and use [17].

### 2.2 Product Semantics

Inspired by semiotics, product semantics is the study of product meanings, forms, and their use within a context. It is the study of how people make sense of and understand products through their forms. It supports designers as they consider the product understandability from a situated user perspective throughout the design processes. It suggests designing artifacts not only based on their functionalities, but also their contextualized meanings in use, in language, in life cycles, and in an ecology of other artifacts [20]. Using a product semantic perspective for XAI builds upon general concerns of XAI, but it focuses on the user experience and understandability of a given AI system based on user interpretations of its material and formal properties.

### 2.3 Aesthetics and Ecological Thinking

Aesthetics takes a more holistic view to forms, in that the form of an aesthetic object goes beyond merely its structure or its physical or visual shape and it includes its meaning and interpretations and it represents its aesthetic content [3]. Therefore, aesthetic accounts often unfold as imaginative interplay between material particulars and interpreted wholes [2]. Aesthetic perspectives are multidimensional, simultaneously perceiving, analyzing, interpreting, and evaluating objects that have the potential to extend our experiences and to enrich perspectives and improving concepts of reasonable action. In that regard, aesthetics is seen as an ecological and relational way of understanding and interpreting the world, in which materials, objects, relationships, and meanings create a web of interconnected and more-than-human whole [18].

## 3 STUDIO STRUCTURE

The studio will be organized in two parts. The first part will be focused on position paper presentation and a panel discussion. It will be about broader discussions and provocations on graspability and AI, their roles in everyday life and in connection with different AI systems. The second part will feature hands-on activities, in which participants will build physical prototypes as proposed explanation modalities for specific AI systems.

### 3.1 First Part

#### *Kick-off and short presentations*

We will kick off the studio by a short presentation from organizers, presenting the topic, schedule, and activities of the day. Then each participant will introduce their position paper or interactive demo in a 10-minute presentation. We will ask each participant to end their presentation by stating how their position contributes to explainability in AI and how TEI can be included in the future development of the position.

#### *Panel discussion*

In the panel discussion, we will invite researchers from design, humanities, and XAI to discuss forms as explanation modality in AI systems. Questions will hinge around the plural interpretations of forms and their meanings and how they can be applied to specific human-AI interactions and applications. The meanings include both abstract and concrete ones, such as form as order [1]; form as geometrical shapes; form as unified experienced wholes [3]; form as assemblage of tangible properties perceived by our senses [30].

**Table 1: Studio Schedule**

| Time(CET)           | Activity  | Format  |
|---------------------|---|---------|
| <b>First part:</b>  |   |         |
| 09:15 09:30         | Introduction to the studio: presentations, studio schedule and activities | Hybrid  |
| 09:30 10:30         | Presentations: position papers and demos                                  | Hybrid  |
|                     | <i>Break</i>  |         |
| 11:00 12:00         | Panel Discussion  | Hybrid  |
| 12:00 12:15         | Conclusions for virtual attendees   | Hybrid  |
|                     | <i>Break</i>  |         |
| <b>Second part:</b> |   |         |
| 13:15 15:00         | Group activities: ideation, sketching and prototyping                     | On-site |
|                     | <i>Break</i>  |         |
| 15:30 16:15         | Presentations and discussions: pitch presentations                        | On-site |
| 16:15 16:30         | Conclusions   | On-site |

### *Reflections and conclusions*

A short discussion session will follow, where we will encourage participants to share their final thoughts and reflections; then we conclude the first part of the studio.

## 3.2 Second Part

### *Physical forms as explanation modality for Recommender Systems (RS)*

In the second part of the studio, participants will be engaged with hands-on activities. They will work in groups on specific use cases and use scenarios. We will focus on Recommender Systems (RS) as an example of everyday use AI system. RS are unsupervised machine learning models used in a variety of applications, such as music streaming, e-commerce, and news. RS suggests contents to the users based on their behaviors and interactions with different contents. Some RS can also use contextual information such as time of the day in order to suggest a more personalized content to the users. However, RS is not always understandable or predictable and it can operate with bias. While this may not be an issue in music RS, it may have more serious consequences in news RS or in medical applications [9].

To explore this area, each group will be assigned with a specific use case (e.g. music RS, news RS, etc.) and a use scenario. We will provide ideation cards, form giving process guidelines and visual scenarios for each group, which illustrates a specific use scenario and users in a context such as home or work environments. We will use and test a set of ideation cards developed by the organizers, inspired by Hornekcer's Tangible Interaction Ideation cards [16].

The form-giving process will be inspired by Di Mari and Yoo's grammar of physical forms to guide the practical form giving processes [24], and product semantics to design physical forms in relation to other artifacts and the context of use. We will consider RS techniques such as collaborative filtering; content-based filtering [29]; hybrid filtering and critique-based RS techniques [6] as well as culture-aware and context-aware RS [26] to inform design process. We further bring into discussions the issues related to RS, such as filter bubbles, gender bias [10] and noise in data, among others, to generate ideas. Each group will start the ideation and

design process and will make physical prototypes using the provided notions, tools and materials (e.g. card-boards, sketching tools, papers, electronics, etc.).

### *Discussions and presentations*

After the group activities, a discussion session will follow with all participants. Participants will present their work and will discuss how their experiments can contribute to GAI in a short pitch presentation. Then, the studio organizers will conclude the studio on-site.

## 4 PLANS FOR DISSEMINATION

This second edition of this studio will explore the physical forms as explanation modality in Explainable AI, drawing upon perspectives from TEI, product semantics, aesthetics and ecological thinking. The results of this studio will be submitted as an article to a magazine (e.g., ACM Interactions) to inspire and invite more HCI and design researchers to engage this research space. In addition, the website of the studio will be updated with the outcome of the workshop and its future developments.

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