Affordances Based on Traces of Use in Urban Environments

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ABSTRACT

Traces of use in public environments show the behaviour patterns of the masses. Taking advantage of this quality, we want to use such traces as design tool to indicate possible interactions in e.g. newly built areas while keeping a natural and calm environment. Due to current lacking knowledge about such traces, this work aims at understanding the perception of traces of use in public places. Therefore we collected a total of 182 pictures of traces of use in urban environments. A focus group discussed and classified a preselected set of pictures. In an online picture viewing survey, 18 different pictures were reviewed for pattern identification (N= 32-52). Overlaps were visualized in heatmaps. We contribute an analysis of which public traces of use are easy to recognize with great agreement and which are not.

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Authors Keywords

Traces of use; Public environments; Urban environments; Study; Online Picture Viewing;

INTRODUCTION

"The best user interface is the self-effacing one, the one that you don't even notice." This statement was made by Weiser [21] about the introduction of ubiquitous computing. While it certainly holds true in many aspects, it also creates a problem: Interfaces that can't be noticed, might be difficult to be used. For our research, we envision unobtrusive interfaces embedded in existing public environments and ask the question how they can provide affordances that make them appear interactive. By analysing traces of use in urban environments, we identify familiar patterns of use that serve as design tools for indicating interactive places and objects with shared social value [18, 19]. To create unobtrusive interfaces and avoid additional information overflow [4, 20], we propose to seamlessly integrate them into the existing conditions of the target environment similar to these traces of use.

To understand this design opportunity better, we collected about 182 pictures of varying traces of use in public, urban environments. After preselecting 46 pictures, a focus group identified 8 different groups of reoccurring patterns with different emotional or interactive affordances. The patterns of each group were then validated in a quantitative study (N between 32 to 52) in form of online picture viewing. Agreement and disagreements about the identification of the traces of use were visualized as heatmaps.

MOTIVATION

- Providing affordances to achieve a common understanding of how to interact with the functionalities integrated into the environment [5, 9].
- The need to integrate more calm and unobtrusive technology to reduce information overflow [4, 20].
- Sustaining (historical) buildings and places by using them as interface for more modern functions [10], picking-up on the idea of collaborative buildings [17].

CONTRIBUTION

We contribute:

- A novel design research approach by collecting and analysing pictures, which is easy and quick to distribute.
- Traces of use classifications that are either inviting to be touched or which are rather negatively connotated.
- Material qualities and conditions that are counterproductive for interaction design such as broken parts that seem accidental and uncomfortable to touch.

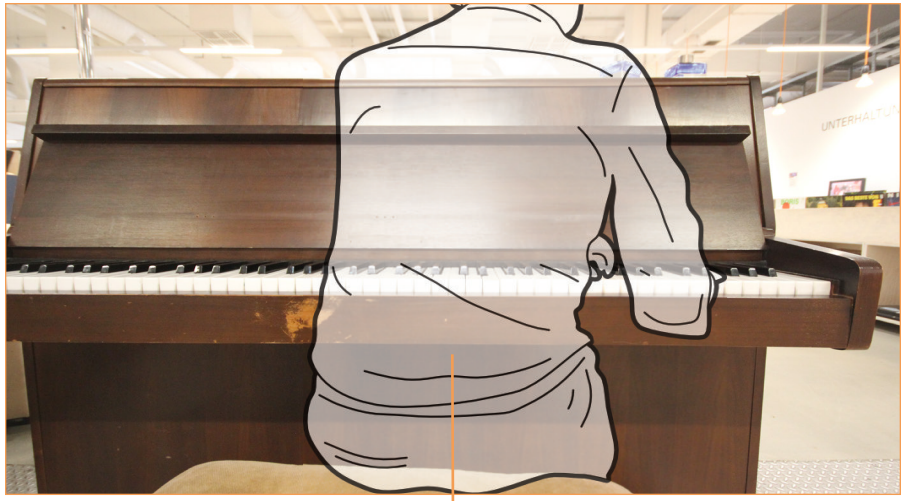
Affordances based on traces of use

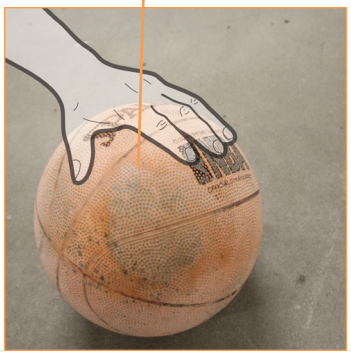
We define affordance according to Norman [14] as the perceived properties of an object or environment, which tell us how it could be used and understood. Prior knowledge or experiences in interacting influence the perceived affordances and connote them with **personal value** [1]. Further, affordance is also depending on context and **intention** of use.

By traces of use we mean perceivable material changes over time due to direct or indirect (which means through another object) repeated human interaction.

Material Conditions

Through the interaction with an object, its material including its structure, form and texture change over time. These changes can affect its affordance as well as the perception of surroundings [16]. Acc. to [8] the visual perception of material conditions is apparently close to the real conditions. This supports our decision of chosing picture viewing as a method.





Personal value of traces of use

Physical properties of an object are interpreted by our theoratical and cultural knowledge as well as our experiences [7]. Accordingly, we bond with objects on a personal and emotional level. We further relate this to the making of valuable memories. Apparently, among other conditions, repetitive activities with social value which influence the personal life also in the now can become valuable memories [12]. Traces of use are indicators of such memories [19] and can hence, have a great meaning for individuals.

Traces of use in public

Traces of use in public or semi-public environments can be caused by a mass of people who repeate the same or similar activities over a certain period of time, as e.g. walking the same path to work every day. We see the potential for such traces to be used to communicate former interaction, potentially connoted with valuable memories.

Conclusions of former use

Tasi and Orth [18] researched the relationship between traces of use on cherished objects and human memories which they state as "ever-changing and embedded with personal significance". Hence, vice versa, affordances of used objects allow assumptions about such relationships and how the objects were used. Here, the presented object shows clearly which keys were used the most. Assumptions about intentions of use and the relationship between user and object can be made.

Approach

We took a total of 182 pictures in 2 cities in Germany. The collection was preselected in a brainstorming between the first two authors.

In the following, a focus group acc. to[11, 13] with 4 experts, two architects, one industrial engineer and one philologist was conducted. The different areas of expertise led to the comparison of different intertwined topics. Participants discussed the picture set of 46 in regard to their associations with the displayed traces. This included topics, such as positive or negative connotations, intentions- and type of interactions that caused the trace as well as context related information. Clusters of traces were created which were afterwards used in an online survey.

The online survey was applied as a quantitative method (max. N=52) to reassure that the same traces of use would be identified as discussed in the focus group. Therefore, participants were asked to paint the traces of use that they recognize in each picture. We used a custom script to evaluate the edited pictures and created heatmaps to analyse the distribution of painted pixels and level of agreement of participants.

While this approach allowed us to evaluate a variety of traces from real life examples, we want to point out that the selection is limited by the subjective perspective by the authors. Further, as the context per trace differed, the framing, scaling and perspective vary per picture a lot. This restrains the between-pictures comparability. However, the focus of this pictorial is on the recognition of traces of each single picture, so that we focus on the advantages of easily distributing, editing and comparing traces of use in this way.

1. Picture Collection

All pictures were taken in public or semi-public places.

2. Preselection & Focus Group

For the reduced picture set, we preselected a set in which unambiguous traces, a variety of locations, positions and types of traces was included.

In the focus group, behavioral patterns of society as well as the quality and application of different materials and intentions of using a place were discussed by participants.

3. Online Picture Viewing & Survey

Particpants were asked to paint areas that they recognized as trace of usd.

4. Heatmaps

Comparing the differently painted versions of each picture, we created heatmaps to indicate highest to lowest agreements.

Results Focus Group

Participant focused a lot on the form and the material conditions of traces of use. When asked why people could have left these traces, they called them “negative”, “positive” “unconscious”, “conscious”, “steady” and “wanted” and discussed their assumptions about the intention of use.

Overall, the focus group clustered the pictures to 8 different groups which showed that the context as well as the type of trace of use determine positive or negative association. Two were ignored in the further study progress: One was titled “accident” and hence, not considered a proper trace of use. The other included just one picture which was called “negative unconsciously”. The remaining groups were called “Nice, that it is used”, “Indifference”, “Positive Conscious”, “Indifference”, “Scratches”, “Patina” and “Lanes”. In a brainstorming session between the two first authors, three pictures were selected for each category. As selection criteria, we considered a variety of camera perspectives, locations and materials on which the traces were applied. The pictures were shown in a fixed order.

Indifference

It was discussed that the feeling of- and taking responsibility for public areas and objects was much lower, in comparison to private use. Instead, perceived mistreatment and usage would rather cause to copy the same behavior and attitude.

The area’s storyline

Considering the combination of context and type of trace, participants made assumptions about the story behind the interaction. The purpose and spirit of a place were important criteria. Hence, pictures from a playground were perceived more positive than from a train station.

Negativ unconscious

Scratches or traces that seemed to be caused through an indirect interaction like through a zipper that is pressed against the backrest of a chair, were associated to careless, but unwanted behavior and rated as rather negative.

Accidents

Some changes in form and material state seemed to have occured through an accident which were not classified as traces of use due to single event characteristics.

Keen to touch

Pictures in which one material had two very different statuses of use (rough and smooth) seemed to trigger their curiosity of touching it.

Material quality

High-quality material that is “nice to look at and touch” such as bronze or ceramic were only positively associated. Instead many negatively associated traces were derived to the bad material quality where traces appear unwillingly and unconsciuously.

Heatmap Evaluation

We defined a methodological approach to collect information to show that people are able to consistently detect traces of use. The approach included data collection, analysis and processing steps which are further explained here. It allowed us to gather insights about users' perception of traces of use in urban environments.

Step 1: Data Collection

Participants had to inspect 18 pictures for traces of use. These traces could be obvious such as the damaged wall paint shown in the picture, but also inconclusive such as the table's wooden surface.

Participants had to paint the identified traces in the detected areas, but not to mark them semantically by adding annotations or marks.

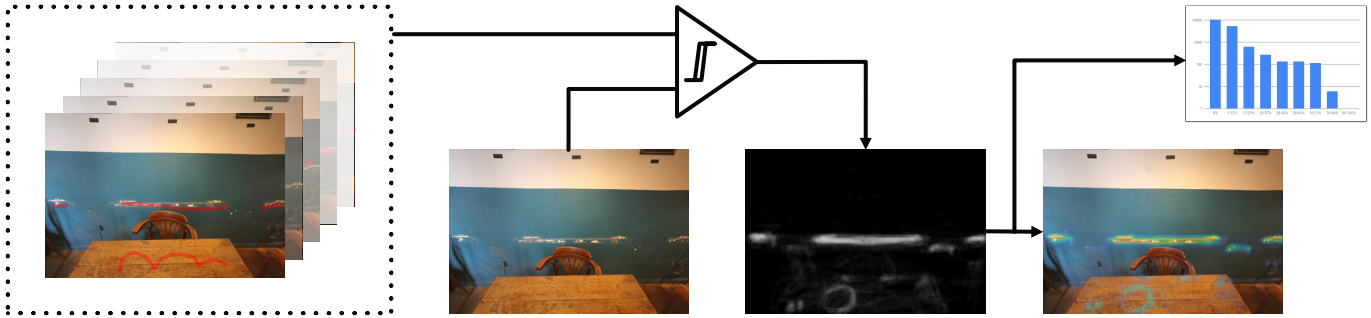
We manually went through all the images looking for wrongly executed markings and removed them from the data set to ensure the highest possible quality.

Step 3: Data Analysis

The generated heatmaps allowed us to analyse users' perceptions of the shown traces and to generate insights about how to reuse them as design strategies.

The maximum heat over a trace shows us the participants' agreement regarding this specific trace of use.

Further, the ratio between the high agreement area of a trace and the surrounding fade out area allowed us to derive assumptions about how distinctly the participants were able to identify and locate the traces.



Step 2: Data Processing

Based on the colour comparison between down-scaled (8%) versions of the reference image and the raw data, a raw heatmap was generated depicting the agreement (0-100%) of all participants per pixel.

Heatmaps using the turbo colour scale plotted onto the original reference images as well as histograms showing the pixel count per agreement interval are generated.

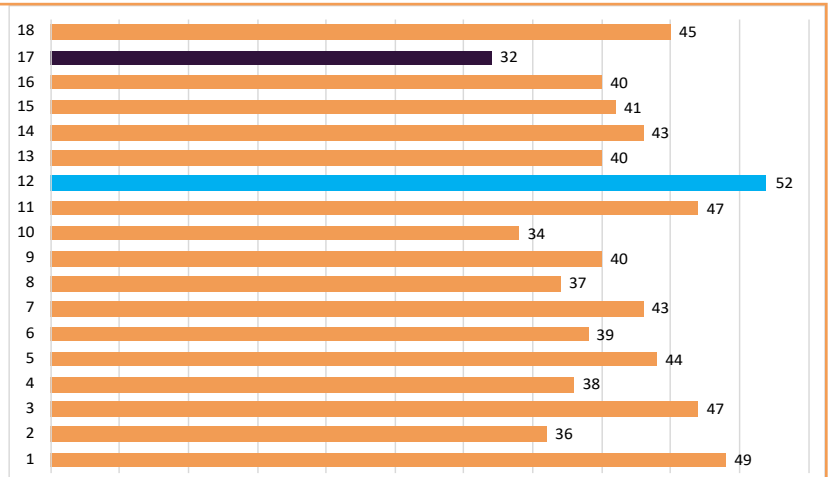
Results

In total, 56 participants contributed to the survey. The contributions we ended up using varied per picture, as the painting behavior differed.

The average number of pictures per heatmap was 42 with a standard deviation of 5. Levels of agreement between participants are shown by histograms analysing the overlapping distribution per pixel. In other words, of the valid total data set per picture, we looked at how many participants painted the same pixels.

Total no. of cleaned edited pictures

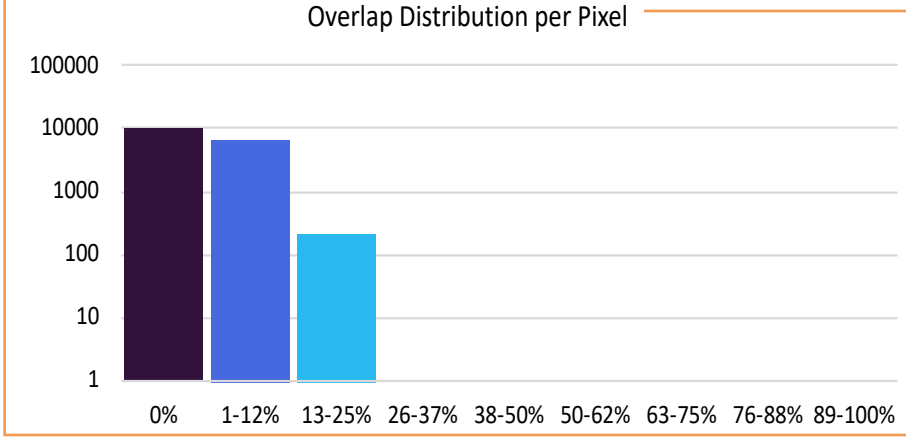
The graph shows the total number of pictures that could be considered for the heatmap creation after the data cleansing. It ranged from 32 - 52 valid data sets.



Histograms

Reusing the same colour coding for the historgrams as for the heatmaps (the turbo scale), we classified the level of agreement of the same identified traces. The different distributions explained how the context of a picture was taken into considerations.

Turbo Scale



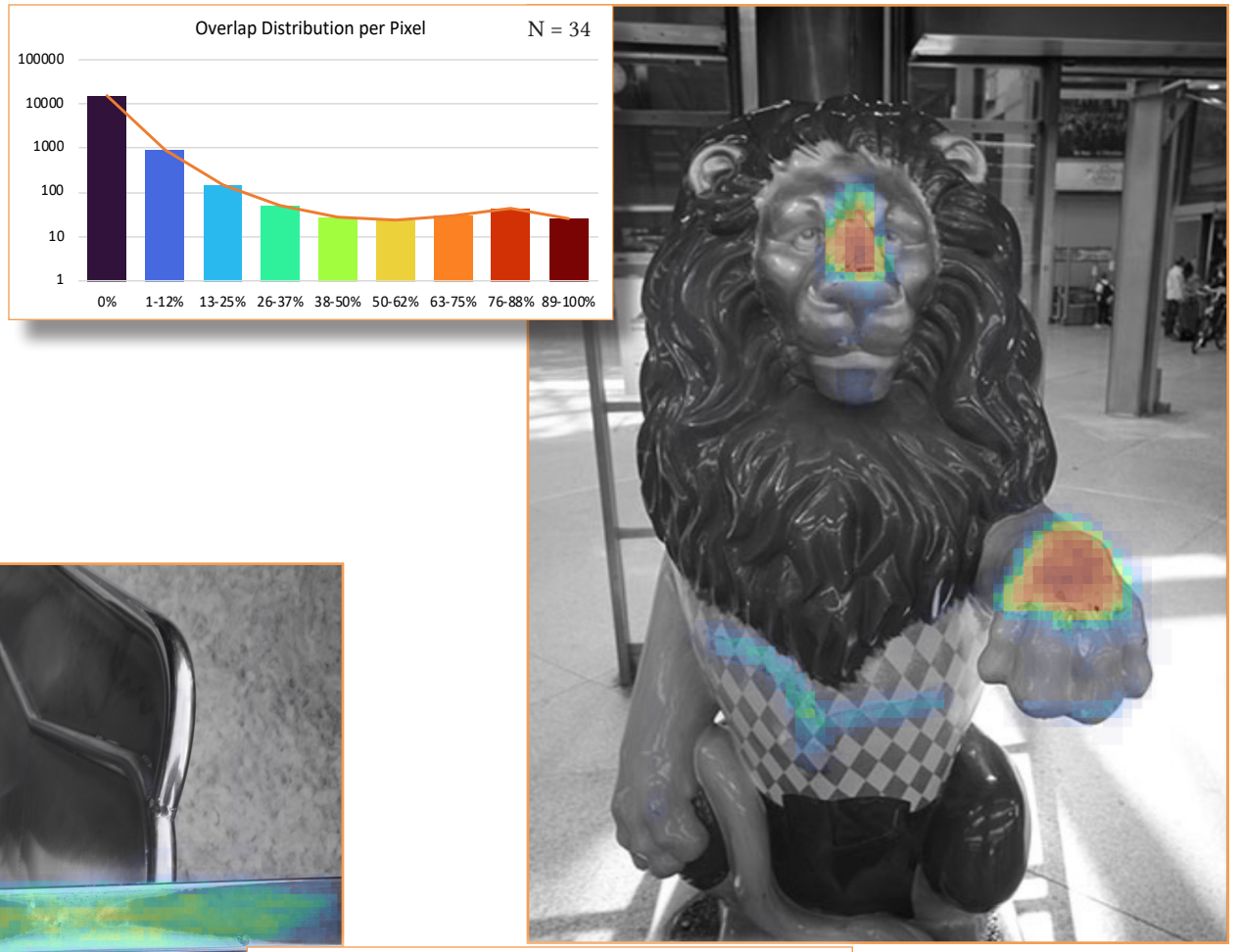
Range of Agreement

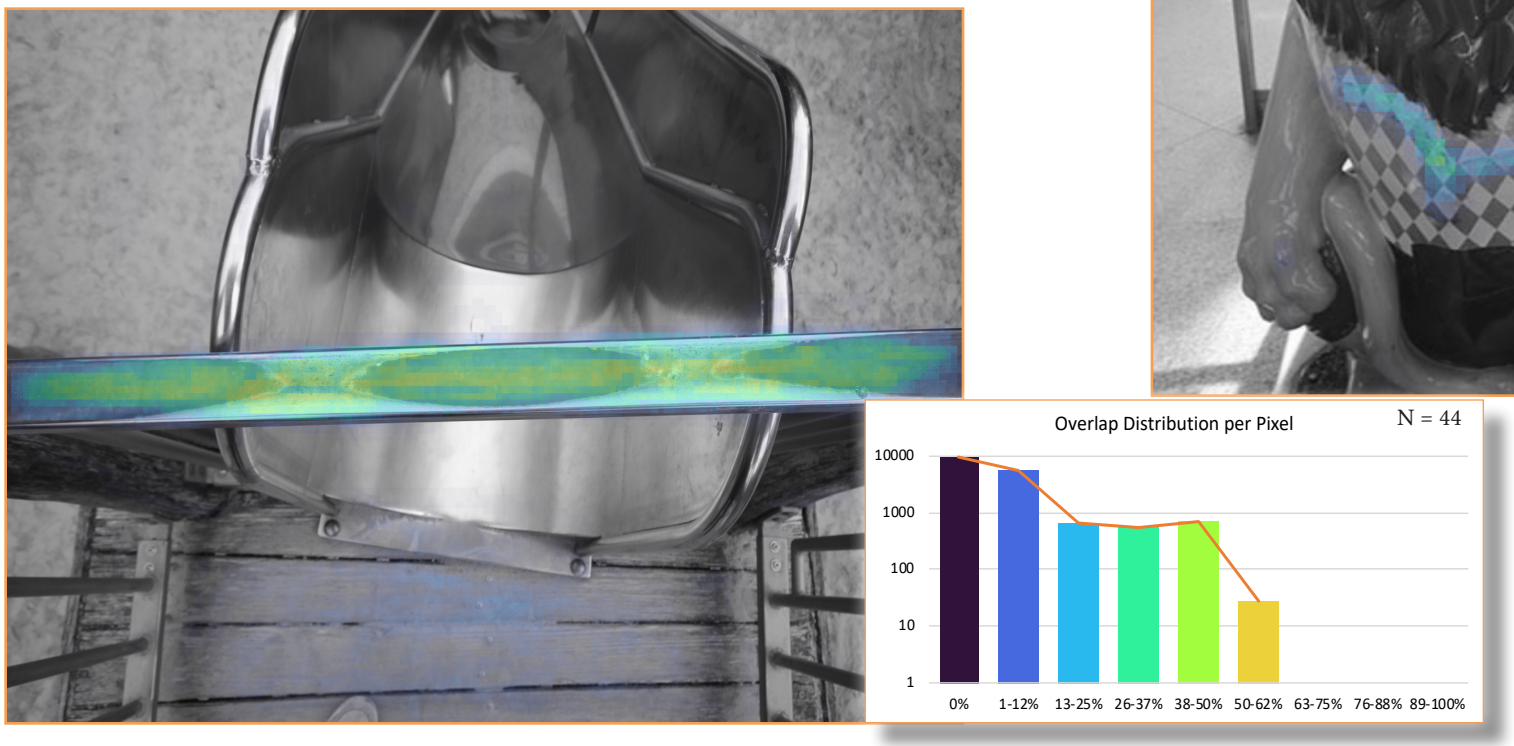
In the left picture, it seemed most difficult for participants to identify the trace of use. It has the least agreement of painted pixels with a maximum of 25%. In comparison, the picture on the right reached highest agrrement with up to 100%.

Agreement & Disagreement

In the picture below, participants painted either the blank areas of the bar or the weathered ones. This opposite understanding is also represented in the distribution graph. The agreement levels from 13-50% are equally distributed, however no pixel showed an agreement beyond 62%. A potential explanation derives from the various types of traces. Dirty traces as well as abrasion are each considered as trace of use. This is an example of a disagreement in interpretation and understanding.

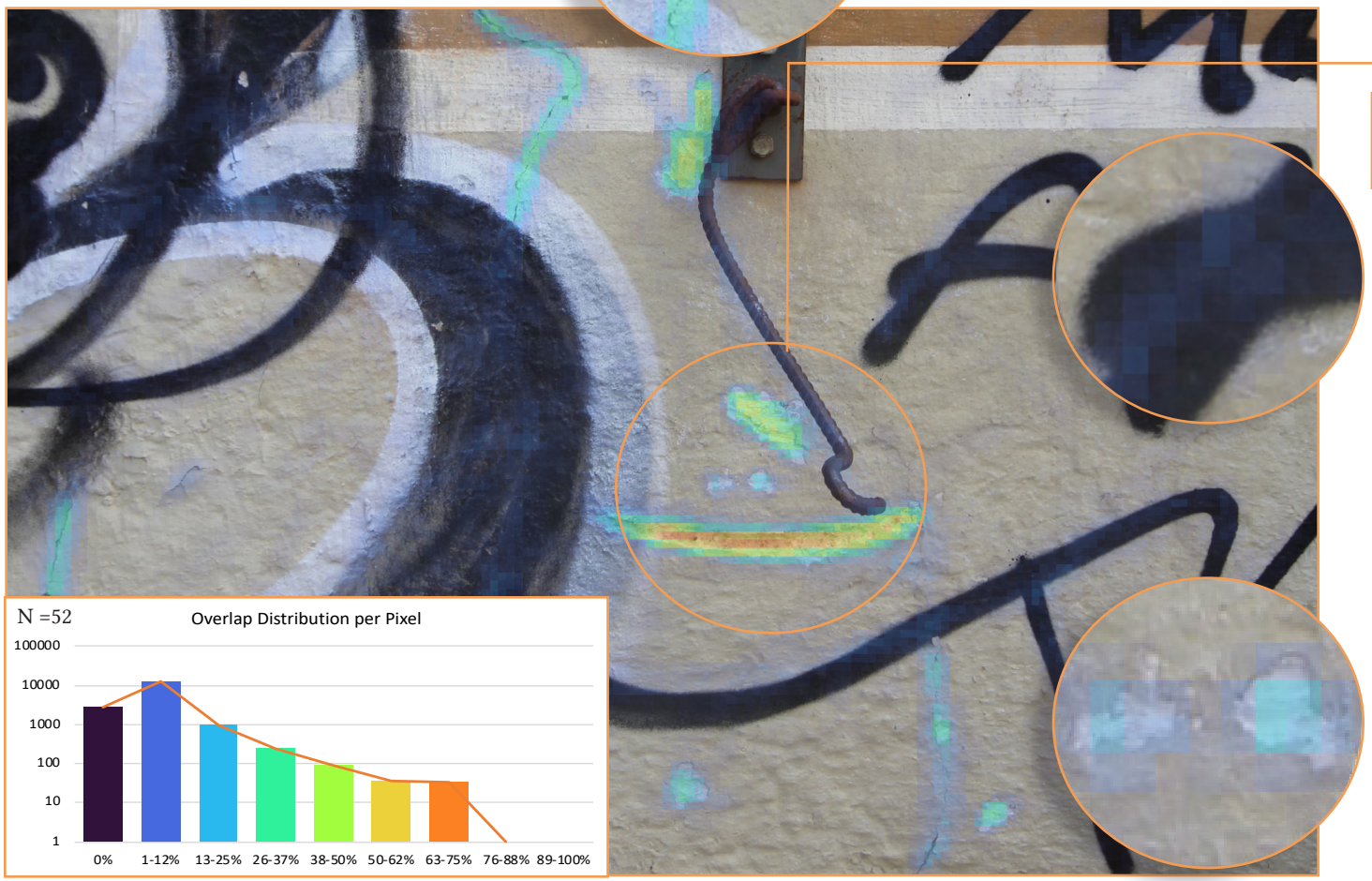
Instead, painted areas in the picture on the right showed the greatest agreement between participants over all pictures about what can be understood as trace of use. In comparison, the object's look and structure was clearly interrupted by the traces. These changes in style did not contribute to the overall look in form of enhancing, emphasizing or complementing it, but rather disturbed the overall form.





Noisy Context

In the picture below, more than half of the total number of pixels were marked as traces of use. While a comparison to other pictures is limited due to the different framing, a comparison of the painted areas allows conclusions about what participants understood as traces of use. The notch by the hook reached up to 75% agreement. While still showing a clear result, the question arises how much participants were distracted by the rather noisy context and how their judgement could change in a less noisy environment.



External Factors

Weather and other physical forces leave traces as well. Physical forces can be part of indirect interactions by humans, like a car crashing into a wall. The distinction between causes of traces requires more in depth analysis. Often, these two families of factors are intertwined in a cause-and-effect relationship.

Depth/Extrusion

Independent if in context of the trace or as part of the targetted trace, differences in depth through scratch like forms or else within the same material showed great agreemenent as identified trace of use.

Graffiti

Traces such as graffiti can be assigned to one-time interactions and are, hence, not included in our definition of traces of uses. Nonetheless, it changes the appearance and the characteristics of a place. As some participants painted over the graffiti as well, we understand that the change introduced through the graffiti contributes to the “used look” of the environment.

Dents

Irregularities in surfaces in form of bumps and dents can be a wanted feature of an object. However, their shape and the form of the edges allow interpretation about their reason of existence. In the picture, up to 25% of participants painted the same dents as trace of use. We assume that participants expected the wall in different conditions in its original status.

Material Qualities

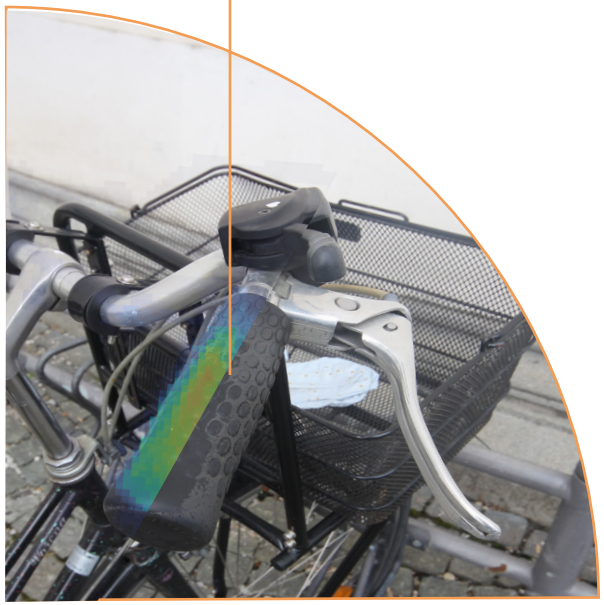
Fisher [7] as well as Rosner [16] emphasise the importance of materials including their qualities in the context of interaction design. Further, physical and visual properties of an object influence how a place is used and understood. This contributes to our idea that traces with a shared, common understanding can be used as indication for interactive areas. Among others, identified qualities are colours, consistency and surface texture. Here, we show material differences marked with great agreement in comparison to the original.

Colours

Areas on which surface colours seemed worn out and showing the original material colour were perceived to a high percentage as trace of use (up to 100% agreement among participants). We assume that colour characteristics such as irregular intensity, saturation or cracks contributed to this perception.

Consistency

Perceived material consistency depends on the kind of material and its ageing process. Materials such as bronze are associated with a certain stability in material consistency. However, Rosner et al. [15] discussed that while the transience of each product differs, none would be eternally stable. According to Giesel and Zaidi [8], soft and flexible qualities are more positively connoted than rough and stiff materials. However, the focus group clustered all stable objects into the class “nice that it’s used”.



Surface Texture

Smooth surface conditions were clearly identified as traces of use by up to 100% agreement. The results were highest if the represented object showed smooth as well as rough textures of the same material. The perceived visual affordance of an object is often depending on layers of shades which convey a certain depth [8]. Additionally, Baxter et al. [2] asked participants to identify traces based on observations. It showed that these kind of object characteristics, including stains, scratches and dents, are easy to identify.

Anticipated Form & Culture

Deformation of material structure and texture is a sign of use, as well. However, heatmap results showed that participants partly completed shapes according to their previous experiences. We assume that we can explain this behaviour with Gestalt laws.

A person's cultural background as well as the context in which a trace of use was located are both aspects that relate to previous experiences. Hence, correlations between cultural context and a trace of use are discussed here.

Gestalt laws

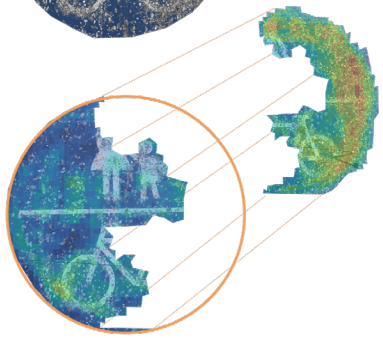
Up to 62% of participants painted the right side of circular street sign which was located on a pavement. Participants focused on completing the circle, instead of painting traces in the surrounding.

Law of Closure

The correct recognition of deformed shapes can be explained by the law of closure [22].

Law of Continuity

Acc. to [3], this law states that smooth and continuous patterns are rather perceived as one shape than discrete ones.



Assumption

For creating design patterns inspired by traces of use can make use of deformed structures as long as the Gestalt laws can still be applied.

Cultural Influence

The picture above shows the face of a lion statue in which participants recognised traces of use with up to 88% agreement. Background to this statue is that it is supposed to be a lucky charm for people touching it [6]. Fisher [7] stated that our cultural knowledge is one contributing factor of how we interpret interaction possibilities, or in other words, relating it back to Norman [14], the interpretation of an object's affordance. In this context, it is rubbing a lion's face for good luck.

Traces For Interaction

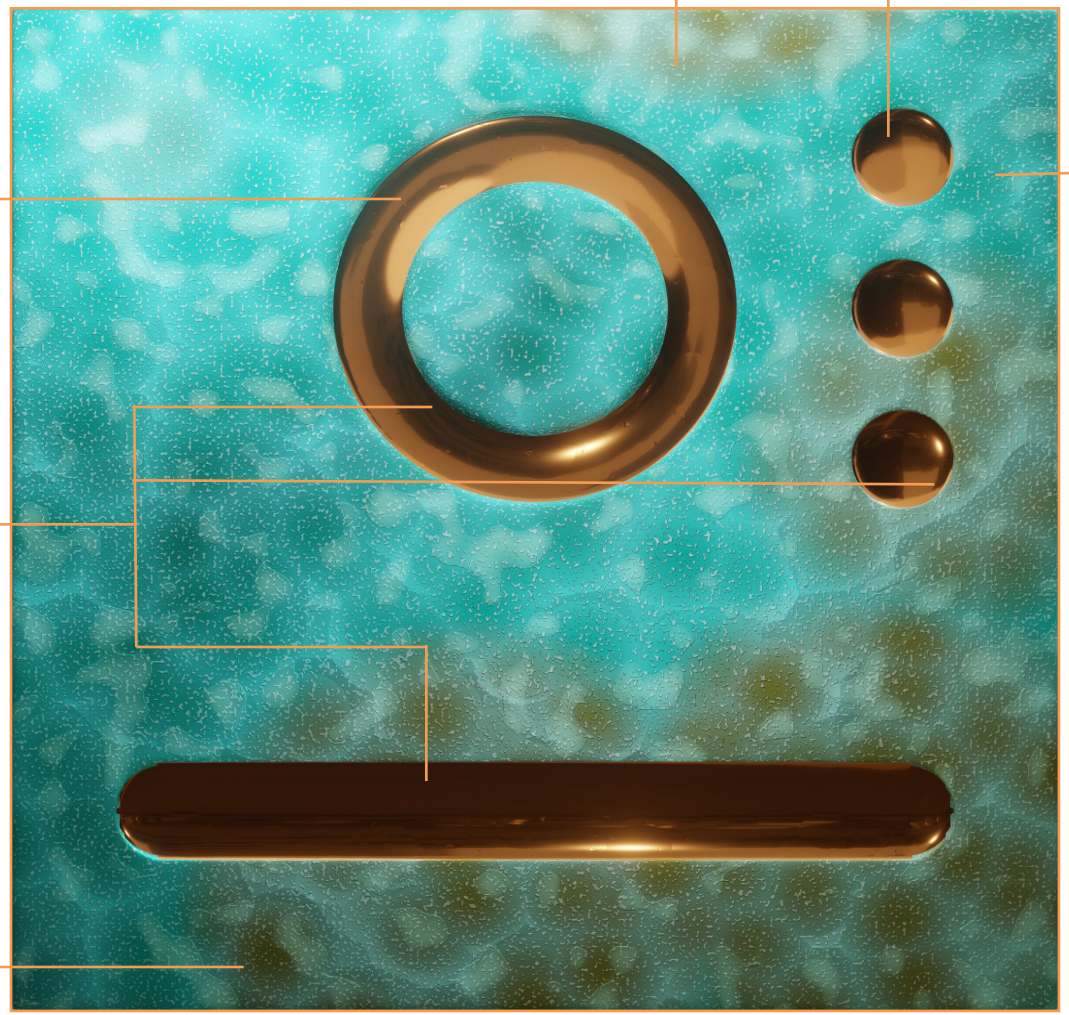
From our observations, we found that different patterns can indicate an interactive surface or a non-interactive surface, as well as interaction types (push, pull, slide etc.) and movement directions. We use these implications to develop the design concept “Traces for Interaction” for unobtrusive interfaces in public places. Here, we show a first draft of such traces for interaction.

Surface Textures

Rubbed off surfaces were clearly recognized as spots where former interaction must have taken place. We want to use this distinction to emphasize control elements. Further, complementary textures can trigger the wish to touch them.

Depth

Extrusion, as a form of adding additional layers of the same material or creating shapes through deepening of the material were both recognized as traces of use which we want to use.



Colour

Worn out colours or the application of different colours next to each other supports the recognition of former used areas and not used areas. It supports to indicate active versus inactive areas.

Digital and physical familiarity

We plan to apply familiar elements such as sliders or buttons for the interaction mode. This is where we bridge known digital elements with familar traces of use to arrive at the traces for interaction.

Distinction

Traces can be caused by other factors, such as weather over time, too. We take this into consideration by overemphasising the control elements. Finding the right balance remains for future work.

Patina

One positively associated characterisitcs was called patina by the focus group. As we want to create interfaces that people like to interact with, keeping such a look could support a positive attitude.

Cultural Context

In future projects, the prototype ideas should serve a specified need, placed in a certain target environment. The meaning of the cultural context of the location influences further design decisions.

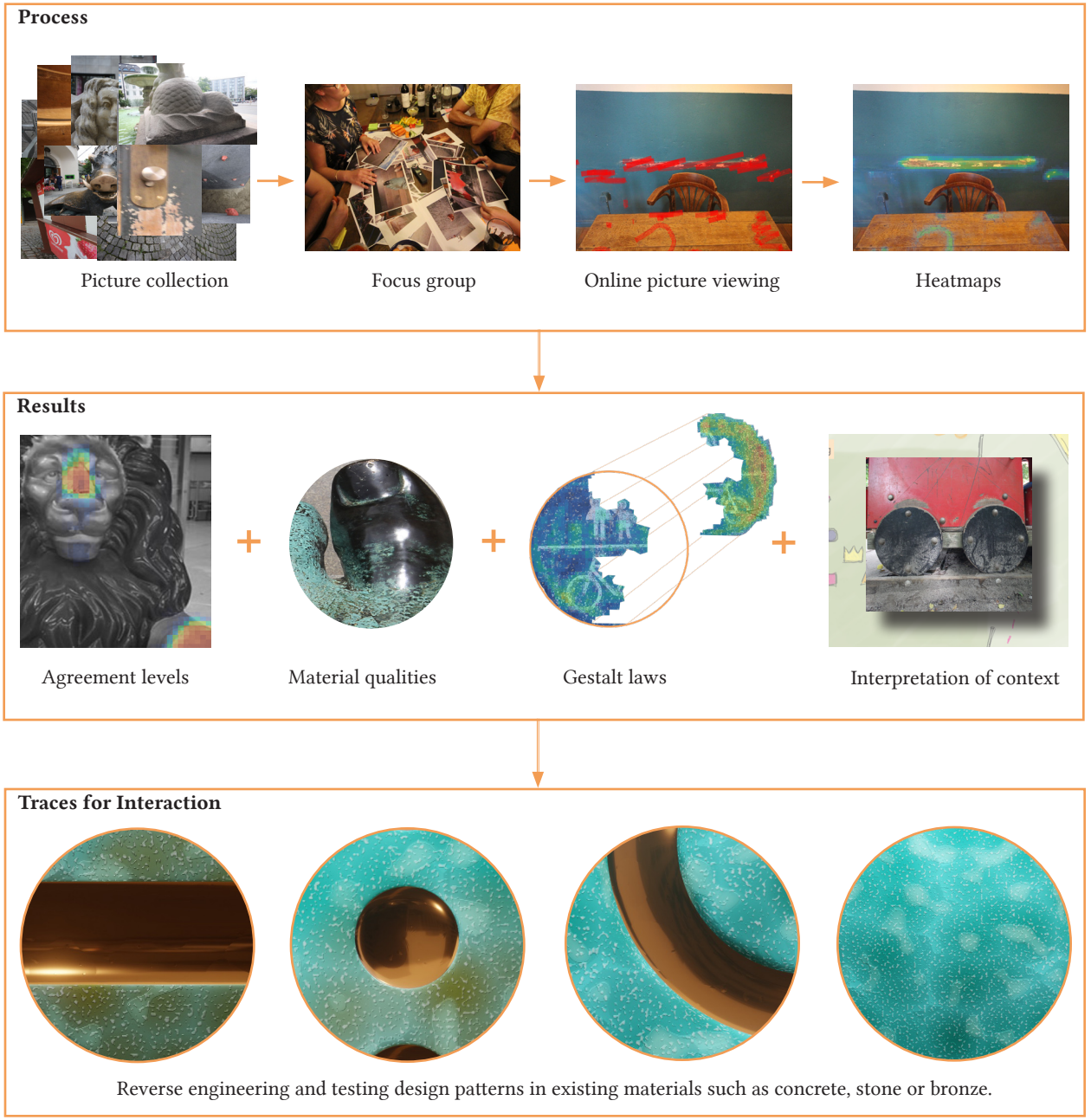
Conclusion and Future Work

We captured a set of 182 pictures showing various traces of use in two cities, categorised them in a focus group and validated the common identification of the traces with online picture viewing. Differences in the results were visualized as heatmaps and levels of agreements as histograms. We then transferred design patterns based on traces of use on first 3D-models.

Traces of use that were identified with agreement were based on material changes such as surface texture, consistency, colour and irregularities. Participants did not differentiate between one time use and a trace of use developed trough continuous use. However, based on the feedback by the focus group, the latter was perceived as more positive and understood as shaping the history and characteristics of an object which should not be restored, but kept as-is. Positively associated traces may trigger the curiosity of touching them, especially in the case of two opposing material texture conditions such as rough and soft. Instead, seemingly broken objects and areas were classified as carelessly treated due to a missing feeling of responsibility or ownership.

Based on the agreements in the heatmaps and the results of the focus group, we introduce the concept of "Traces for interaction". This concept reuses existing patterns of use as design tools to indicate interactive areas in a seamlessly integrated way, wherever this may be desired.

Aiming to validate our results and test our design concept further, we will transfer our design implications into physical prototypes by reusing existing materials for city environments, such as concrete, stone and different types of metal. In addition, we see great potential in our design research approach as a general method for designers to analyse and make use of pictures. Hence, we plan to develop the method further through e.g. counterbalancing the image sequence, improving the explanation about the painting process, and automatizing the graphical evaluation as heatmaps.



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