Alerting Users by Animating Content on a Transforming Tabletop Interface

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Abstract - In this work, we are exploring methods to convey the intentions of a transforming tabletop interface. The goal is to alert people prior to the table's transformation with minimal disturbance during face-to-face communication. A transformable table assists people to form a suitable communication atmosphere; however, sudden transformation may disturb or scare people [7]. To prevent such frustration, we developed a system to animate display content by scaling, rotating, translating and/or rounding edges to alert people. Through a pilot study, we compared the animation alert to traditional visual and verbal alerts and found that the animation alert generates minimum disturbance. Thus, it may be a suitable alert in needs of minimum disturbing over the traditional alerts. As a future work, we are suggesting to investigate how an animation can convey its meaning much clearly and effectively.

Keywords: Human-robot interaction and Shape changing interface

1. Introduction

There are many robots integrate into our home, office, factory, and many other places to assist in many ways such as doing errands and helping manufacture [1,7,8]. Among these robots, a robotic tabletop surface becomes an active research topic [7]. A table is an important social entity, and its shape forms a communication space (e.g., creating focal point of conversational space) and affects the social interactions (e.g., meeting at a long rectangular table where a CEO sits at the edge vs. meeting at a round table) [7].

Alongside with benefits from these robots including a robotic table, some of them potentially introduce safety issues with their physical movement, e.g., a flipped lawn mower robot, a transforming robotic table (Figure 1). Understanding a robot's intention might prevent an accident; however, it is a challenge to develop a generic alert to convey a robot's intention because each robot has different capability and communication channels, e.g., display, speaker, actuator, etc. Moreover, notifying a robot's internal state may annoy people – they get feedback when they do not expect to. Thus, we argue the need of a less distractive yet comprehensive notification.

There are prior studies that explore how a robot can convey its intention to people by having a small behavioral cue [3] and internal state without disturbing people using a machinery attachment (e.g., a tail) [6], a locomotion [5], or nonverbal leakage (e.g., eye gaze) [2]. A robotic tail introduces an additional communication channel between people and the robot [6]. It is a natural looking attachment on a Roomba vacuum machine because of its zoomorphic figure [6]. However, with our tabletop interface it is difficult to provide such natural looking machinery attachment. In another work [5], a flying robot expresses its movement in Laban effort system. It moves, for instance, quickly in a section, and moves powerful in another section, etc. Although Laban effort system is applicable to robots with locomotion, it requires a certain level of flexibility of actuators. Eye gaze is not applicable to robots without eyes. Thus, considering our robotic table's mechanical limitation, we need the other way to convey the robotic table's internal state to people. One way we suggest is an animated display content, where a display content is actively animated with locomotion, which possibly behaves as a small behavioral cue [3] of a tabletop interface without an arm actuator.

Figure 1. TransformTable that opens side panels to transform its tabletop interface.

A table's physicality can smoothly create or guide the

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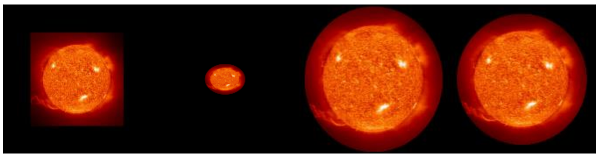

2.a 2.b 2.c 2.d

Figure 2. A Blooming flower animation.

3.a 3.b 3.c 3.d

Figure 3. A deflating balloon animation.

atmosphere of social interactions around the table by having a different shape of its surface [7]. However, the table's transformation can involve physically (e.g., hitting people around it) and mentally (e.g., performing an unwanted transformation) stressful situation. To reduce such stress, provide safe interaction, and convey an internal state of a robot agent, we developed an alert system which animates display content on a transforming digital table to notify the table's transformation. The animation starts prior to the transformation and continues until it is finished. We conducted a small technical pilot study to explore effect of the designed display animations by comparing with traditional warnings, flashing screen and auditory/verbal alerts. The animated display is reported to be a less disturbance alert than a verbal alert; suggesting some further studies of how to develop a pleased and comprehensive animation.

2. Alert System

Our implementation consists of the two main components: a robotic transform table and an alert system. The table, prior to its transformation, posts its intention to the alert system. Then, the alert system expresses the table's transforming state by animating display content, flashing, or playing a recorded verbal warning message, which are defined in human-readable XML format. The alert starts before the transformation and repeats till the end of the transformation.

2.1 TransformTable

We used TransformTable [7] as a platform, which is a wheeled robotic table that can transform to round, square, or rectangle. There are several motivations of transformations such as content-dependent display shape (e.g., the sun or a picture), dynamic management of spatial arrangement of people (e.g., changing number of persons), or guiding social interactions (e.g., conversation or meeting) [7].

For the transformation from square to round shape, the robotic table opens its side panels and brings up the fan-shaped round edges stored inside of the table. Once the edges are up and connected to the four edges of the square surface, the side panels are closed. In the transformation from round to square, each mechanical part is manipulated in the opposite direction. They are intended to offer adaptive collaborative workspace for multiple users around the table, requiring safe mechanical movements while keeping the fluidity of their ongoing interactions. The previous work [7] confirmed safety motions and social impact of the transformation but has not explored how to reduce its interruption effect on people interactions.

2.2 Animation Design

We designed two content animations for the table's transformations: square to round as in Figure 2 and round to square as in Figure 3. These animations are visually exaggerated based on the motion of the mechanical parts (i.e., lifting up and down of the four fan-shape panels) to draw people's attention while minimizing a distortion of display content.

The transformation from square to round by adding four fan-shaped panels expands the tabletop surface towards every direction. We perceive this motion as a blooming flower. The animation mimics a blooming flower by shrinking (2.b) and expanding display content (2.c). Then, as the content grows slightly larger than surface size, it adjusts slowly to the surface size (2.d). By shrinking and grows larger, the animation is exaggerated with bigger motion.

When the table transforms from round to square, it loses the four fan-shaped panels. We found that a deflating balloon has a similar motion – when balloon is losing the air, it shrinks its size. The animation starts by converting to square and expanding overall size in order to exaggerate its motion (3.b). Then, it shrinks slowly like a deflating balloon to the square tabletop interface shape (3.c and 3.d).

2.3 Traditional Alerts

In real world domain, there are many visual and auditory attentions to prevent an accident [4]. Common examples are flashing light in construction sites, rail roads, and school zones, and auditory/verbal announcement in airports, train stations, and school charm bell. We implemented these two alerts to compare with our animated alert.

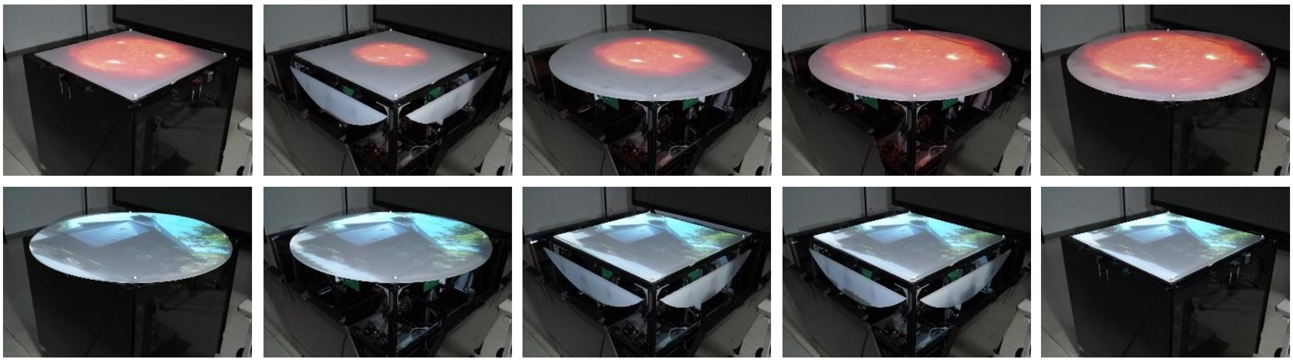

Figure 4. Top row shows blooming flower animation during transformation from square to round and bottom row shows deflating balloon animation during transformation from round to square.

The implemented flashing alert consists of three times of strong flash with short delay. We chose a strong contrast color so that the flash is always notifiable. The auditory alert is prepared with a voice synthesizer. A machinery female voice speaks "the table is now transforming, please be aware of it." The voice is played inside of the table so that people perceive it as the table is speaking. As the animated alerts do, these alerts are repeated until the transformation is finished.

3. A Pilot Study

To explore the impacts of the implemented content animation alerts, we conducted a pilot study. We recruited five male participants as an initial step of the investigation (avg. age=22.2). This study simulated a usage of the TransformTable from the previous work [7]. That is, we expected that people are in communication in a crowded environment and the table would decide to transform its tabletop surface to assist a group of people. We played a background noise recorded from a crowded environment by an external speaker. In this initial investigation of how an animation alert performs, we simulated a group conversation by asking a participant to read text on a screen across the table (where another person may stand) out loud. During the task, the table displays related contents to the topic. It transforms to the round or to the square shape after a certain time period with one of the alerts. For each type of alerts four transformations are performed. A participant is asked to answer questionnaires with 7 Likert scale after each type of alerts. To minimize learning effects, we have counter balanced the order of alert types.

3.1 Result

ANOVA shows the main effects for the two questions of 'aware of danger' ($F(2, 14)=4.412$, $p=0.037$) and 'distracting attention' ($F(2, 14)=9.579$, $p=0.003$) (Figure 5). A post-hoc comparisons using t-test with Bonferroni correction on 'aware of danger' shows that the auditory alert ($M=6.60$, $SD=0.55$) had a significantly higher rating from the flashing alert ($M=4.60$, $SD=0.89$), $p=0.035$; however, had no significant difference against the animation alert ($M=5.60$, $SD=1.52$), $p=0.490$. Another post-hoc comparisons on 'distracting attention' shows that the animation alert gave ($M=3.40$, $SD=0.89$) significantly smaller distracting effect than the auditory alert ($M=5.60$, $SD=0.55$), $p=0.003$ and had no significant difference with the flashing alert ($M=4.60$, $SD=0.89$), $p=0.104$).

After the study, we have collected open comments from the participants. An interesting quote from two participants is about anthropomorphism/zoomorphism. P1 said "because the table speaks (i.e., auditory alert), it is like a living object" and P2 said "animation was interesting and it makes me feel like the table is alive."

3.2 Discussion

From our pilot study, we found that people may be aware of danger with the auditory/verbal alert; however, the auditory alert may distract people compared to the animation alert. This could be because a person has a difficulty to ignore when understandable verbal information is provided. On the other hand, the animation alert had sufficient level of understanding and was the least distractive alert among the three, which shows the potential of an animation alert. With further investigation, we may be able to develop animation alerts comprehensive and aesthetically pleased.

4. Limitations and Future Work

In this work, we developed content animations, used them as an alert, and compared to traditional alerts (flashing and auditory/verbal). Due to a small number of participants, it may not be proper to conclude our findings. However, it shows the potential of the animation alert and suggests further investigation along

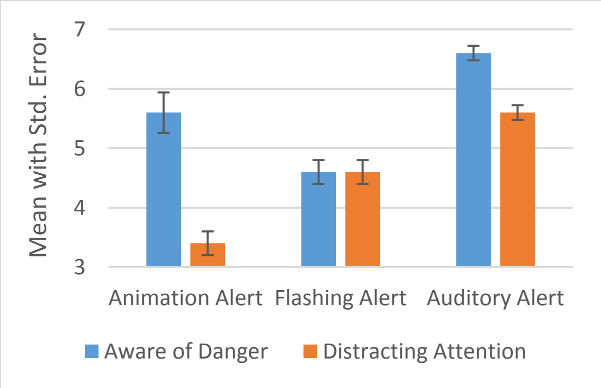

Figure 5. Two questions, reported the main effects.

this notion of research.

A possible limitation of the simulated group conversation task is that participant's eye-gaze and attention were not natural compared to a real group conversation. A real face-to-face group conversation will be made in our future work.

In our animation design, we explained how we perceived the table's behaviors and tried to match closed real world metaphors. Even though our animation is not created by an artist, it was still able to convey some level of awareness and understandings to people. It will be interesting to see how an animation created with collaborations of a professional artist performs. In addition, this process will allow us to develop various animations in different concepts or purposes including anthropomorphism and social acceptance.

5. Conclusion

In this work, we developed an animation alert system for a transformable table to prevent people's physically and mentally stressful situation. The animations are designed by mimicking motions which can be found in the real world. We compared them to traditional alert systems: flashing and auditory alerts. Through a pilot study we found that an auditory (verbal language) alert is comprehensive, yet it distracts people's focus in their main task. We also found that an animation alert is significantly less distractive compared to the auditory alert. This result shows that the potential of an animation alert and suggests a deeper investigation in this topic to unveil impacts of an animation alert.

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