TILTle – exploring dynamic balance

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Abstract. In this paper we introduce a novel interface for exploring dynamic equilibria using the metaphor of a traditional balance scale. Rather than comparing and identifying physical weight, our scale can be used for contrasting digital data in different domains. We do this by assigning virtual weight to objects, which physically affects the scale. Our goal is to make complex comparison mechanisms more visible and graspable.

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1 Introduction

The notion of balance is fundamental in human culture and is rich in social connotations. Also within the field of computing and technology, comparison and optimization are central concepts. In many cases digital information is classified and sorted out based on certain predefined criteria. However, these processes are usually concealed from the user, resulting in little understanding of these hidden operations.

Another aspect that influences the transparency of these processes is the number of elements and dependencies involved. While comparison of individual elements is easy to understand, balance between complex systems can be much more opaque. In voting procedures, for example, algorithms for comparing votes sometimes lead to paradoxical results. In spam filtering, the large number of parameters makes the classification of email messages difficult.

In this project, we have developed a tangible interface in the form of a physical scale that aims at making concealed and complex comparison mechanisms more visible and graspable. The scale allows the playful exploration of the concepts of

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balance and contrast by letting the users define different criteria for comparing elements and assign virtual weights to them. Connected to this central idea of virtual weight for expressing balance are the following two aspects:

First, the tight coupling of physical properties and the computational domain – both physical and virtual objects have physical effects on the scale, with both physical and virtual properties of the object contributing to the computation.

Second, our interface makes the temporality of computation visible – the result is not instantaneous, and changes of virtual weight over time are reflected in the behavior of the scale.

2 Related Work

The concept of Tangible User Interfaces was first defined by Ishii: [TUI's] *will augment the real physical world by coupling digital information to everyday physical objects and environments."* [3] Since then, a variety of different TUI's has been designed and the definition and boundaries of this UI genre have been broadened. Today, TUI's can be used as explicit interaction interfaces, as well as more implicit, ambient interfaces.

So far, the concept of physical weight has been explored in a few projects. In the project i-LAND Streitz et al. at the GMD Institute sketched the vision of intelligent furniture that can sense and identify objects placed on its surface through their physical weight [4]. In the same way, Carvey et al.'s Rubber Shark as User Interface identifies objects by their weight and associates them with digital content [1]. However, a scale for virtual weighting and its use as an ambient device has not yet been suggested.

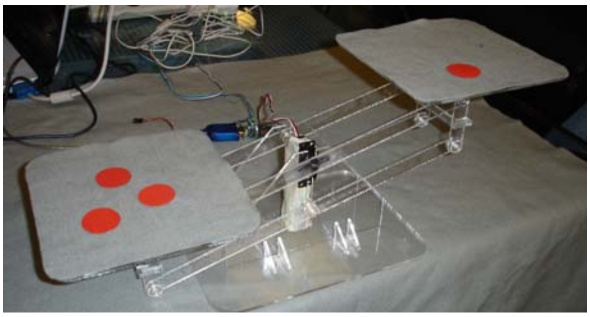

Fig. 1 Comparing physical tokens, using red color as a comparator.

Interaction Scenario

On a broad level, the user interacts with the system by placing objects on the platforms of the scale and defining a comparison metric. Thanks to the implemented application, the system recognizes the objects and their manually assigned virtual weights, and calculates the equilibrium according to the specification in the application. The position of the scale is then changed to express the result (figure 1) by setting the position of a servo motor.

We developed a number of scenarios that exploit the possibilities of the interface in situations where the distribution of balance is not obvious. These examples illustrate how the tangible aspects of the scale can be used to visualize many different aspects of a complex system or process; its contents, relations to other parts within the same system or process, and the balance between the different parts. Hopefully, the interface could make these factors both more visible and graspable, as well as function as a foundation for further discussions and analysis. The scenarios also show that the scale has the advantage of being usable for both individuals and for groups of people:

Comparing social networks

The first application is situated in the domain of social network analysis. Comparing properties of social networks is often ambiguous since different metrics, i.e for centrality, are used and many contributing parameters are involved.

A simple task could be to maximize the spread of information in a social network by picking the right people to send it to. The tokens would represent the group of people that can be directly contacted, whereas their extended network is augmented by the scale (figure 2).

By comparing size and qualities of the resulting graphs, different combinations of people in the initial group can be evaluated. For example, one group could reach a maximum number of people after one step, whereas another group might have less, but higher connected people in their distance one network. By adding another step to the augmented network, this change would become visible.

Again, this could be calculated through network analysis, but structure and properties of larger graphs are particularly hard to judge intuitively. For this, a device like the scale would provide valuable feedback. During all stages the size and/or inherit balance of the networks is expressed through the position of the scale. By removing and adding persons to the network the impact of this change on the whole system can be explored interactively. The sketched example is of course trivial, but. thanks to the abstract interface, the scenario could easily be changed or extended. Special qualities of nodes and edges can be taken into account. Also the position of the dots could be assigned a meaning; the two separate planes be connected.

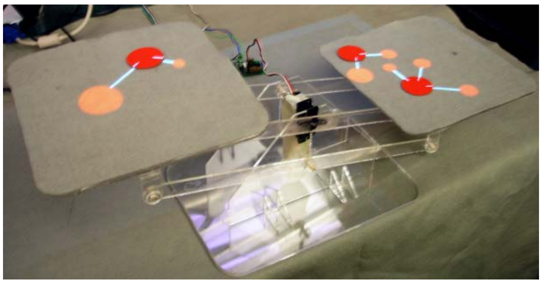

Fig. 2 Augmentation of the physical tokens with virtual elements, influencing the balance.

Pro and Contra – decision making processes

Another approach focusses on contrasting arguments. The two platforms of the scale represent the pro and contra sides of the decision process. Imagine somebody asking the question “Should I get married?” or “Should I quit smoking?”. In this scenario, the user would put red dots, one at a time, on the two platforms of the scale and watch the scale balance the “weight” of the arguments. For example, one argument for getting married might be “I’ll get to throw a big party”. As the user puts a token on the pro-side of the scale and pronounces the argument, the application can adjust the virtual weight by projecting a larger sized dot on top of the token. “Heavier” arguments generate larger dots. Again, the virtual weights have to be assigned manually by creating an application that has some knowledge about the comparison criteria and objects. In this particular case, the application requires information about the user’s preferences. The application is thus used to clarify and contrast personal values that the user may or may not already be (partly) aware of.

Temporality through ambient display

Once a meaning is assigned to physical tokens, their virtual weight might change over time. In this respect the scale works as an ambient display. The balance situation is glancable from a distance; detailed information, displayed on the platforms, is revealed upon closer inspection. We could for example compare the performance of two soccer teams, with the results of individual games projected on the platforms. For example, when a team is currently dominating the game, the side of the scale that represents that team tips over.

System Design

The scale prototype is constructed out of acrylic plastic, including four horizontal arms to provide a horizontal orientation of the platforms. A servo motor is rigidly attached to the upper arms at the central axis of the scale. Attached to the servo motor is a counterweight, that rests in a vertical position and makes sure the scale swings back into horizontal position when the platforms are empty. By rotating the counterweight, the balance of the scale is shifted and tilting occurs.

This actuation makes it possible to tightly couple the computational results of the comparison with the physical effects on the scale and vice versa.

The technical setup includes a top projection onto the scale, an USB webcam close to the projector to detect the tokens and a computer running control software written using the computer vision software platform eyesWeb [2]. The software calculates the color distribution on both scale platforms, and adjusts the servo motor rotation accordingly.

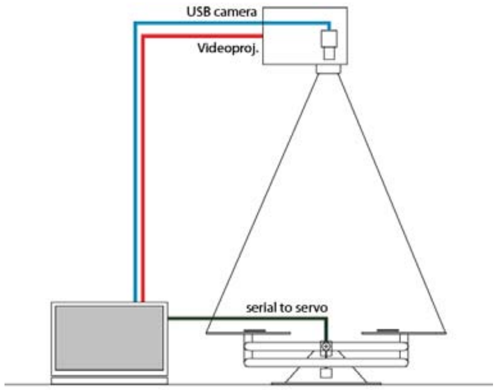

Fig. 3 System setup of the prototype.

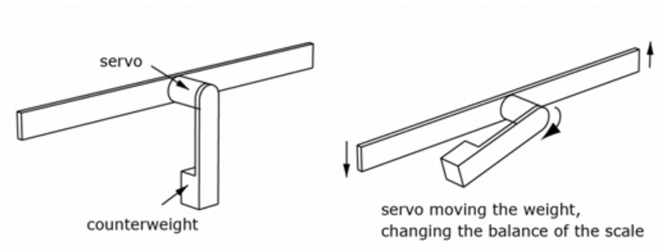

Fig. 4 Actuation principle – the balance is affected through rotation of a counterweight at the center of the scale, preserving the characteristic oscillating behavior.

Assigning weight to a token

We evaluated three different approaches for expressing weight:

1. RFID tags as tokens read by a reader underneath each scale platform.
2. Using optical markers on the bottom of the tokens, recorded from a vertical camera underneath the scale.
3. Tracking individual colors and shapes, i.e. comparing the amount of a certain color.

For our working prototype, we decided to choose the third option for a couple of reasons. First, while using markers requires explicit assignment of virtual weight, color is an inherent quality that allows to express virtual weight in an implicit way. Second, as an inherent quality, color establishes a strong causal and perceivable relationship between the token and its virtual weight. Third, color gives us the highest flexibility in choosing objects as possible tokens and makes it even possible to project colored images on the scale that contribute to the virtual weight. By using computer vision, the amount and intensity of color is measured on both sides of the scale

Color as an indicator offers us a number of parameters: the area occupied by the specific color, its saturation, lightness and hue. With saturation, area and lightness contributing to the virtual weight (within the limitations of computer vision systems), we found it appropriate to map the hue to the different comparison metrics. However, as a starting point we used only the amount of red as our indicator of virtual weight.

Augmenting the weight through virtual elements

We used a vertical projection to display virtual elements on the surface of the scale platforms. Since these elements are equally visible to the computer vision system, they also contribute to the total weight on the scale and influence the balance of the system. This approach enables more dynamic interactions by introducing a feedback channel - the virtual weight can be changed in various ways over time. For example, a colored halo can be projected over a physical token in order to increase its virtual weight. Hence, the interaction can be controlled and manipulated by both the user and the system.

Remote interaction

Since physical tokens and projected elements both contribute to the balance of the scale in the same way, the interaction can take place in both the physical and the digital domain. This also allows remote users connected over a network to interact with the scale by adding or removing virtual elements or changing the weight of physical elements on the scale. A possible application could be tele-voting, where the scale offers feedback about the current amount and balance of all submitted votes.

3 Future plans and extensions

System extensions

At this stage, our implementation does not account for the real weight of physical tokens. In a future implementation the scale could incorporate this information, thus extending the interaction possibilities even more. Two different directions are interesting:

1. The physical weight of the compared objects could be compensated by the counterweight of the scale, removing the influence of physical weight. Even a very heavy object would be evaluated only based on its virtual weight.
2. The physical weight is introduced as an additional parameter contributing to the balance in a controlled way. For example, imagine an application where both the physical weight of a food and the nutrition facts as virtual weight contribute to the balance of a diet plan.

Future applications

While the basic principle of our scale is very simple, our proposed interface is quite flexible and can be extended in different directions. Especially the juxtaposition of different metrics to the same dataset as well as mixing metrics is an interesting field to explore. For example, we could compare the environmental impact of a company with its profitability.

Conclusion

The interactive scale presented in this paper was designed based on a high-level idea of comparing entities or objects. Thus, as we have shown, a number of different applications and interaction styles can be applied to the interface.

The output can be both implicit and explicit. Most importantly, the balance output changes over time based on data provided by the system; the weight of objects can grow or diminish, and the comparison can be changed. Our digital scale is a dynamic system.

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