

Instructions immersed into the real world— How your Furniture can teach you

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ABSTRACT

In this paper we show a simple way to immerse instructions into the real-world. In particular, we propose to enhance static affordances of objects by using LED's attached to the objects. Using the example of a flat-pack furniture demonstrates how to guide and teach the user during the assembly.

KEYWORDS

instructive interaction, physical interaction, dynamic affordance

INTRODUCTION

In previous work [1] we introduced the notion of proactive instructions that service users specifically to their needs in the current situation. Using a piece of a flat-pack furniture we showed how to determine the assembly actions the user is performing: sensors attached to unassembled furniture parts can recognize the user's actions and send the data to a separate computer. This computer holds an assembly plan, which contains all possible states of assembly similar to a finite state machine. In the first state all items are unassembled, subsequent states are reached based on the user's physical actions. The final built up state becomes valid if all assembly steps have been performed properly. The underlying principle is that the system can track, by deploying sensors, the user's assembly actions and give recommendations specifically to the user's needs in the current situation.

Presenting these recommendations to the user in a proper way is crucial. Augmented Reality (AR) is very established to visually integrate virtual knowledge into a user's physical environment. However, AR is cumbersome and typically computationally expensive. Audible instructions offer a cheaper way of immersion but have to tackle with the problem of addressing the appropriate parts by a vocabulary the user is familiar with or has to learn before. There is the possibility of presenting information on a screen, as in our prior work [1]. However, the integration of instructions with the task remains unsolved.

This paper studies how affordances of physical object can be exploited and enhanced by dynamic cues: LED's attached to the parts draw the user attention to and signal the next action.

SELF-DESCRIPTION OF PHYSICAL OBJECTS

An ideal design should not require any instructions at all: by simply looking at the physical objects the user can guess and understand the functionality. For this phenomenon Gibson coined the term affordance [2] and it was widely spread in HCI by Norman: "Affordances are perceived properties of an artifact that indicate how it can be used" [3]. Affordances are static properties of physical objects that can be perceived by a user. Furthermore, these properties can invoke a user's mental model explaining functionality of the object and possible actions. Depending on the properties of the object and the experience of the user, affordances cannot always be easily perceived and may require additional signs: instructions.

Instructions change over time as they depend on the current state in the task. Consequently, this paper proposes to enhance static affordances of objects by dynamic signs that give additional hints to the user adapted to his situation: instructions should mediate the dialog between the user and the physical objects. This introduces dynamic affordances as proposed in [4].

DESIGNING LEARNING-BY-DOING

People learn to do things by hearing, being told or instructed, seeing, being shown, or by doing. Despite of individual differences for one mode or another, learning by doing is often very important. A user recognizes something novel ("I see two screws and two boards...") guesses the next appropriate action ("...perhaps the screws fit in here..."), executes the action ("...let's put in the screws...") and is immediately rewarded by discovering if the guess was correct (or wrong). Ideally, instructions provide hints that subtly but infallibly guide users toward correct conclusions. This requires three principles that support learning by doing [5]: *explorability*, *predictability*, and *intrinsic guidance*.

Explorability enables users to explore, experiment, and discover functionality without penalization of unintentional or mistaken actions. In particular, this requires infinite-level undo and redo operations in a coherent and consistent manner. *Predictability* builds upon intuition: a user can draw conclusions based on first impressions without extensive thought or chains of reasoning. Accordingly, familiar things must behave as expected and novel or unfamiliar things must behave in ways that are reasonable and immediately understandable. *Intrinsic guidance*

provides help as needed without requiring any special action or initiative on the part of the user.

FURNITURE INSTRUCTIONS

For the furniture application we identified five types of feedback the user should receive:

1. direction of attention
2. positive feedback for right action
3. negative feedback for wrong action
4. fine grain direction
5. notification of finished task

This enables users to explore how the furniture has to be assembled. Users unwrap the flat-pack and their attention gets directed immediately (1) to the parts they are supposed to start with. User's actions, such as turning and moving boards are sensed and blinking green light patterns indicate which edges have to be connected in which manner. If boards are aligned in the proper way, a synchronized green light pattern (Fig. 1) indicates a well performed action (2).



Fig. 1: Flash patterns: right/wrong action

If the user takes a wrong action, a red light pattern appears (Fig. 1) reporting a mistake (3). Additionally, a green flash pattern shows the right alternative (2). After boards have been aligned together in the right way, individual green lights direct user's attention to the holes where the screws have to be inserted and tightened (4). Once the final assembly state is reached, synchronous flash patterns on all LED's indicate that the task is finished (5).

These light patterns extend an parts' static affordances and can teach the user in a learning-by-doing manner how parts fit together: As a physical notion of undo and redo, attached boards can be continuously detached and rearranged, which fosters *explorability*. Furthermore, the LED's also contribute *predictability* to the assembly as red (green) light immediately indicates a right (wrong) action. *Intrinsic guidance* is provided by dynamic instructions that adapt to the current assembly state. This allows the user to take any sequence of actions without being constrained to a certain predefined linear sequence.

SYSTEM ARCHITECTURE & FUNCTIONALITY

We have developed a first prototype to display the instructions dynamically for a flat-pack furniture [6]. For sensing functionality accelerometers reveal orientation, force sensors measure screw tightening, and IR sensors measure co-location of boards, see [1] for details. Sensor data processing and wireless communication is established by the Smart-Its platform [7].

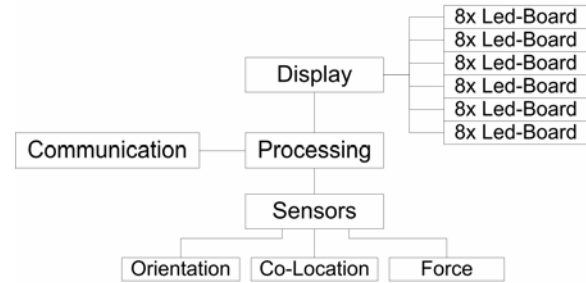


Fig. 2: Architecture Diagram

For the output functionality we have developed a custom layout board carrying eight dual green/red LEDs. Those boards are attached to the connecting edges of each furniture part (Fig. 3).

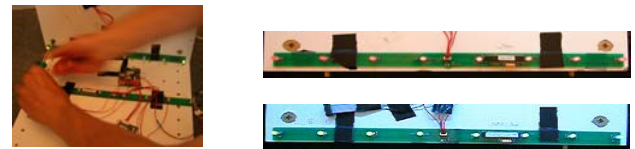


Fig. 3: Prototype: Guidance through LED's

CONCLUSIONS

This paper demonstrates how static affordances can be enhanced by dynamic cues mediating the interaction between users and physical objects. By augmenting parts of a flat-pack furniture with sensing capabilities and LED's we demonstrated the feasibility of this approach. This augmentation of objects allows to integrate instructions directly into the objects, gives the user the flexibility to draw own conclusions and provides intrinsic guidance if appropriate.

ACKNOWLEDGEMENTS

The Smart-Its project is funded in part by the Commission of the European Union under contract IST-2000-25428, and by the Swiss Federal Office for Education and Science (BBW 00.0281).

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