# Augmented Automation - Mobile AR for Improved Intelligibility and Control in Ubiquitous Automation

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## ABSTRACT

We are surrounded by an increasing number of cheaply produced "smart" products which promise the (semi-)automation of tasks. Many of these products have usability issues due to limited and/or poorly designed input and output opportunities which hamper intelligibility and control. In this position paper we propose "Augmented Automation" as a solution to this problem. Augmented Automation uses mobile Augmented Reality to provide contextual guidance to users of difficult-to-use smart products. Using the example of an automated pet feeder, we illustrate that Augmented Automation goes beyond showing static user manuals placed in 3d contexts. We stipulate that it must be able to create and present a summarized model of the product's internal state and help users in mapping their goals to operating steps. We conclude by outlining resulting challenges and requirements for creating an Augmented Automation platform.

## KEYWORDS

Automation, augmented reality, intelligibility, instruction

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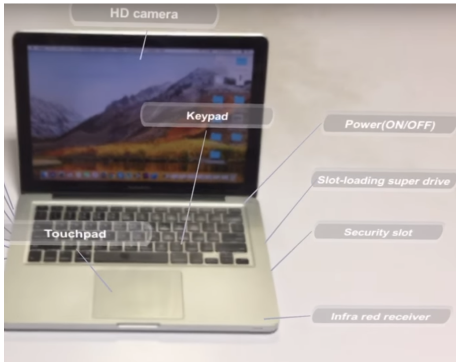


**Figure 1: AR-based interactive user manual for a notebook computer (**https://youtu.be/aQyH7CQPVcA**).**


**Figure 2: AR manual and explanations in the "Ask Mercedes" app (**https://youtu.be/YKSYWrXsLyE**).**

## INTRODUCTION

Automation is a success story. From early steam engines, first factories with assistive technologies, automobiles and automation in agriculture to household appliances: Automation and the "age of machines" have been changing our lives tremendously.

The current generation of automation devices are computation-controlled machines. Most of the computation and control mechanisms of today's everyday devices are built on low-cost hardware. To save production costs they include only low-resolution displays and processing units which are incapable of managing sophisticated user interaction. As a result, it is to often too difficult for users to benefit from the "smart" functions these devices provide. While the design challenges of interactive everyday objects are well understood in the HCI community, thousands of new low-cost "smart machines" are put on the market without due consideration of fundamental HCI aspects.

In this position paper we argue that mobile augmented reality (AR) can be an efficient approach to improving intelligibility and control of (semi-)automated products and that it can support users in interacting with them despite the products' usability deficiencies. Only recently, we have been observing the emergence of mobile AR apps in the consumer market for related instruction purposes (Figures 1 and 2). We argue that with the right standards in place, *Augmented automation* could go beyond simple instructions and provide a path towards inexpensive, but usable automation in consumer objects.

In the following paper we take as reference Don Norman's framework of Human-Machine interaction to explain HCI challenges of interacting with the current generation of low-cost "smart machines". We analyze the HCI deficiencies of a recent smart product with automation features to then discuss how mobile augmented reality can be used to overcome them. Finally, we illustrate how AR could be used not as "fixing strategy" for badly designed everyday appliances, but as a strategy to produce automated appliances that are inexpensive but still provide an adequate user experience.

## USABILITY HEURISTICS FOR EVERYDAY AUTOMATION

Don Norman has been a tireless advocate for usable everyday devices. His books have influenced the thinking and writing of many people in the field of HCI. We claim that the analysis and recommendations he laid down in "Design of Everyday Things" [4] are well-suited for deducing usability heuristics for ubiquitous automation. In a related approach, Schmidt and Herrmann refer to Shneiderman's Golden Rules of user interface design when discussing interfaces for automated systems [5].

A central observation in Norman's book is that users of interactive systems need to cross the Gulfs of Execution and Evaluation (often repeatedly) to achieve their goal (cf. Figure 3). Norman's model of human-device interaction also provides more detail on the steps involved: Before carrying out their first set of actions, users need to clarify their goal, create a rough plan of their actions, specify

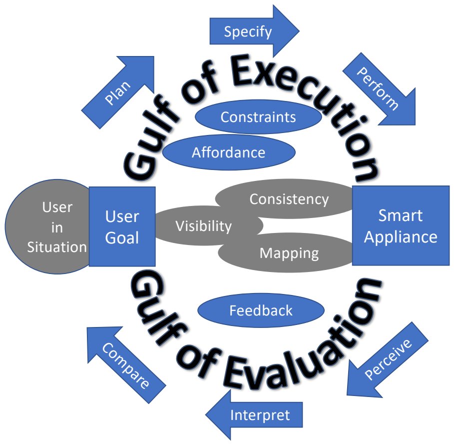


**Figure 3: Norman's Gulfs of Execution and Evaluation.**

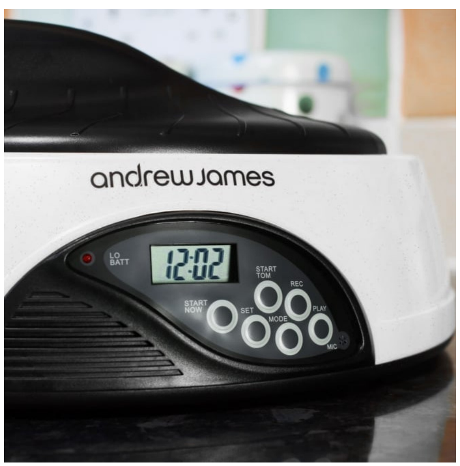


**Figure 4: Example for a low-cost automated device: a programmable pet feeder.** (https://www.andrewjamesworldwide.com/)

the planned actions in more detail, and only then perform their actions. This is what Norman calls "Crossing the Gulf of Execution". After users have performed an action (or a planned action sequence) they need to evaluate whether they are now closer to the desired state – that is: They have to cross the "Gulf of Evaluation". In order to do this, users first need to be able to perceive the state of the device, then interpret their perceptions,and finally compare whether their action(s) brought them closer to their goal.

From his analysis, Norman derived a set of six heuristics (or recommendations) for the design of "everyday things" (Figure 3):

- **Visibility**: The relevant state of the system should be visible at all times.
- **Consistency**: Layout, labels, controls etc. should be arranged, named, and behave in a consistent way.
- **Mapping**: Layout, labels, controls etc. should be arranged, named, and behave in a way that makes them easy to understand and operate taking into account users prior knowledge and the current physical context of the interaction.

These three recommendations provide the basis for the next three recommendations: Affordance, constraints and feedback:

- **Affordance**: Controls should "advertise" their function properly and should be easy and efficient to operate.
- **Constraints**: Devices should be designed in such a way that error avoidance is prioritised over error detection.
- **Feedback**: Devices should provide immediate feedback. Users should be supported in interpreting what has happened, in detecting and correcting potential misconceptions, unintended actions, and maloperations. They should also be supported in undoing unintended actions to "get back on track".

## AUGMENTED AUTOMATION: MORE THAN A SMART INSTRUCTION MANUAL

Using AR to create virtual and contextualized instruction manuals for appliances and technical maintenance has been proposed and studied before (cf. [1–3]). Results of user tests indicate that the support it provides is more effective than the one provided by paper manuals and instruction videos. Doubtless, providing support for the creation and display of "Smart Instruction Manuals" is important, yet Augmented Automation cannot stop there: It has to go beyond placing static instructions in a 3d context.

To outline the opportunities of Augmented Augmentation in a practical context, we chose a semi-automated everyday object which is admittedly not as widely used as other devices: an automatic pet feeder (Figure 4). It can be configured to provide a dog or a cat with specific amounts of food at given times. In Table 1, we summarize several usability problems of this device (which also become apparent in the official support video https://youtu.be/Ofat1-r0KTg) with regard to the aforementioned heuristics and outline how an AR app could improve intelligibility and control of the device.

As pointed out above, Augmented Automation provides users with information about the device's state at a glance and it helps users to map their goals to actions performed on the device. Thus, Augmented Automation must be able to dynamically extract, combine and visualize device status information. Similarly support for planning requires guided information collection and (simple) automatic action planning in response.

**Table 1: Pet Feeder Usability Challenges and AR Opportunities**

| Usability Heuristic | Pet Feeder Problem | AR Opportunity |
|---|---|---|
| Visibility of State | Display of pet feeder state (e.g. current feeding schedule) is distributed over seven screens | AR App collects information and shows an easy to understand summary |
| Affordance Mapping | Buttons have modes: Buttons do different things in different contexts; Button labels are confusing in some contexts | AR App overlays context-dependent annotations to visualize the button functionality |
| Feedback Mapping | Display contains hard to understand icons without text labels | AR App annotates icons with proper context-dependent text labels |
| Constraint | Efficiency buster: Programming may be aborted without intention by pressing the wrong button | AR App can indicate "dangerous" buttons in such situations |
| Make Planning easy | Planning is difficult: Number of feedings per day and portion size need to be planned out before starting the programming of feeding times. E.g. Feeding a 100-lb St. Bernard dog its daily portion at noon requires a setup that differs significantly from programming a morning and evening feeding for a Chihuahua. | AR App can walk a user through a short Chatbot sequence to inquire the necessary data for planning out the programming steps for the user. |

## PRACTICAL IMPLICATIONS AND OUTLOOK

In professional and industrial settings, dedicated data glasses are typically used for AR-based training and instruction tasks since they allow for hands-free operation. For consumer contexts smartphones and tablet computers are more suitable AR devices due to their prevalence and reasonable price.

With the appearance of more and more smart products with (semi-)automated features, it becomes apparent that a separate mobile AR app for each product (such as the "Ask Mercedes" app) is the wrong approach. Instead, one universal app which implements a (to be) defined standard for Augmented Automation seems more promising. The support of this standard by a product could be communicated by a specially designed visual AR marker. In order to give helpful insights into an automated system's current state and intervention options, the aforementioned standard needs to include visual (e.g. LED) and/or wireless interface between the device and the mobile device.

Furthermore, an Augmented Automation platform must support the simple creation of AR content for explaining and supporting a product's automation features. The available toolkit should contain a basic common set of visual objects to support the user's recognition, yet should still allow for brand-specific extensions in order to be of interest for larger companies.

Finally, the needs of users with disability, such as visual impairment, must be taken into account when designing a platform for Augmented Automation services. Similar to Microsoft's *Seeing AI*, an Augmented Automation app should provide the option of speech output to explain automation features to visually impaired people. The aforementioned visual marker could also feature embossed elements to ease the recognition by visually impaired users.

## REFERENCES

[1] Lars Müller, Ilhan Aslan, and Lucas Krüßen. 2013. GuideMe: A Mobile Augmented Reality System to Display User Manuals for Home Appliances. In *Advances in Computer Entertainment*, Dennis Reidsma, Haruhiro Katayose, and Anton Nijholt (Eds.). Springer International Publishing, Cham, 152–167.

[2] Tam Nguyen, Dorothy Tan, Bilal Mirza, and Jose Sepulveda. 2016. MARIM: Mobile Augmented Reality for Interactive Manuals. 689–690. https://doi.org/10.1145/2964284.2973807

[3] Tam V. Nguyen, Bilal Mirza, Dorothy Tan, and Jose Sepulveda. 2018. ASMIM: Augmented Reality Authoring System for Mobile Interactive Manuals. In *Proceedings of the 12th International Conference on Ubiquitous Information Management and Communication (IMCOM '18)*. ACM, New York, NY, USA, Article 3, 6 pages. https://doi.org/10.1145/3164541.3164592

[4] Donald A. Norman. 2002. *The Design of Everyday Things*. Basic Books, Inc., New York, NY, USA.

[5] Albrecht Schmidt and Thomas Herrmann. 2017. Intervention User Interfaces: A New Interaction Paradigm for Automated Systems. *interactions* 24, 5 (Aug. 2017), 40–45. https://doi.org/10.1145/3121357