

# Smart Shelf: Report

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## ABSTRACT

We are on the apex of interaction technology integration with every analogue system that is used in our daily life. Working in big lab with lot of consumable equipments or finding a product in a supermarket is really a big deal. It's really hard for a person to find an object from a gigantic shelf. Also, it's hard to keep supply continuous of consumables by checking every individual slots. Sometime, it's impossible. To ease the hard work of management and user we introduce *Smart Shelf* that will bring smoothest interaction between shelf and human. Here, we present the overall framework, related work and the time line to implement a prototype of *Smart Shelf*.

## ACM Classification Keywords

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Smart Fabrication, Smart, Shelf, Drawer, HCI, Human Computer Interaction, Physical Computing

## INTRODUCTION

Today the word *Smart* is almost everywhere. There are *Smart Homes* and *Smart Fabrication*. But from the last few years, HCI researcher have developed new interactive interfaces, synthesize from different perspective of humans for example Psychology, Economically and Social that can be integrated with modern technologies (Ubiquitous technology). People prefer to use these technologies but sometimes face problems to obtained desired results. For example, most of the time people don't like to use shelves, because it is hard to find something. By using ubiquities technology, combined with technologies of the *Smart Home* and *Smart Fabrication* domain an interactive shelf, called *Smart Shelf*, can be developed. This shelf can enhance the utility of regular shelves. This report describes the approach of the implementation of the *Smart Shelf*. The report discuss different approaches of the interactive design, how the *Smart Shelf* is implemented and how to interact with it. One focus is the interaction of users and operators with the shelf. In the end there is an evaluation of the design decisions regarding the project and an outlook for further work.

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## Problem

Most people when they hear about a shelf they think about their bookshelf or some shelves in the kitchen. Almost everyone who have a bookshelf searched at least one time in his/her life for a book in it and wished to have a guideline how to find it the fastest way. Imagine big shelves with a lot of small drawers. Every drawer is only labelled with a small name that describes what is in that drawer. Searching for items in these shelves can be hard and cost a lot of time. An additional scenario is if you apply this concept to big warehouses with hundreds of shelves and more drawers or places where you can place items. Finding an item in such a warehouse can be still harder.

Shelves used in companies or research institutes bring more problems to the surface. Often there are shelves used for storage of electronic components <sup>1</sup> for example. The drawers contained in these shelves are often a lot and small. Searching for a specific item/drawer in such a shelf with for example fifty drawers can be exhausting. But this is not only one problem. Is the searched drawer found, the contained items are maybe out of stock and the user wasted his/her time. This is not only exhausting, it is also wast of time if the user could directly see if the searched item is out of stock.

Not only warehouses or storage rooms with shelves have those problems with the inefficiency in finding items or the premise if one item is out of stock. The same problems appear in retail. Customer which can't find their favourite product in a shop are unsatisfied. Maybe they go to another shop and don't come back. This problem can be tackled with *Smart Shelves*, too. The shelf itself could detect if some products in it are only available in a small amount. In this case the shelf could order new products or at least send an information to an operator who can order supplies. With this strategy there will be no more empty shelves in shops and customers can find their favourite product all the time.

*Smart Shelf* should be a solution for these problems. It could observe the amount of items in itself, help people to find products and also order supplies if the amount of items is low. The project described by this report tries to give a solution for the mentioned problems.

## RELATED WORK

There are several development work happened last few year in human computer interaction(HCI), home automation and embedded technology. A big set of these work is giving intelligence to rigid objects and allow human to communicate

<sup>1</sup>e.g. Resistors, Capacitor, Micro Controllers or Integrated Circuits

with them and vice-versa by applying noble HCI techniques. Moreover, post-WIMP devices also offer some features that can be integrate with the modern computer technology development(Ubiquitous computing). However, this post-WIMP GUI concept only applicable if there is a metaphor available in digital or analogue world. For example, searching the meaning of a word in digital dictionary(e.g:Smart phone dictionary). We want explain decent amount of successful research work that overlap at least in certain area with our Smart Shelf framework; However, there is no implementation or ground work fully overlap with our concept. A technical definition of our project is "Combining different interaction technique to innovate a device that follow the guideline of ubiquitous computing".The most related topic that are already known by design community are: QR code for presenting information, Automatic amount calculation, Controlling device.

### QR code for presenting information

Now a days application of QR code become very popular and common due to the smart phone technology. Now people don't need to type search. Pressing a key is enough to get information based on QR code. A very innovative application is using QR code in library management. In a case study 'Application of QR Code Technology in providing Library and Information Services in Academic Libraries" by Sandeep Kumar Pathak showed that important information can be presented by QR code and user can easily get all those information by scanning QR code. We are implying this idea in to completely different perspective. In our case every drawer will have individual QR code. Each code will represent individual information about items stored in the drawer.

### Automatic amount calculation

One major objective our implementation is representing empty or not empty drawer. As it's a very ground level work of many automation project, there are many project information available regarding weight measurement. However, in our project we are counting the objects based on the overall weight. We don't see this sort of work is not very common to automation community.Although, the most related work to that sub task is counting weight based on resistive sensor. An example of this work presented in *circuitdigest.com*:Arduino Weight Measurement using Load Cell and HX711 Module. Here they use Load Cell, but we will use resistive load sensor to calculate the weight signal.Also, their project does not include counting.

### Controlling Device

The most important human to machine interaction task in this project is giving command to the system. There are several way to build up the this interaction system:one could be developing from scratch and another is building up over existing individual system. It's very common in Internet of Things (IoT) community to to use a smart phone for controlling a electronic system.For example there are lot of projects that use android devices for home automation. However, Our approach is similar but objective is completely different.



Figure 1. Example for used Shelf as prototype

We see there are many existing work happened in granular level, but here we are bringing these granular ideas to build completely a new noble system.

### CONCEPT

This section describes the basic concept of the *Smart Shelf*. The basic idea of the Smart Shelf is to enhance the interaction with shelves to work with these more effective and to improve the interaction. To satisfy these objectives some core features are proposed in this section. Figure 1 shows a similar shelf used for the project prototype which is small but satisfies the requirements for this prototype. However, one important fact which should be considered is the scalability. The applied techniques should be feasible in a technical and economical way.

The first problem the Smart Shelf wants to address is the fact that it is hard to find a specific item in a high amount of drawers. To do this we propose visual feedbacks combined with an user interface to submit search queries. The user interface can be used to insert a search word, for example the name of the searched item. This search query results in a visual feedback on the Smart Shelf, or in detail on the specific drawer where the item is contained.

The user interface will be provided as webapp. The platform independence of a webapp leads to this design decision. In a first iteration mobile apps are considered, but were discarded because of the platform dependency (Android, Apple iOS, Microsoft Windows, etc.). Additionally, more features are provided by the webapp. Overall, it provides all functionalities to interact with the Smart Shelf. The search, control the shelf or getting more data about different items. For getting more information about a specific item the user interface provides additionally to a datasheet-like page the capability to scan QR-Codes. These QR-Codes are mounted on each drawer

and encode the id of the drawer. A central server, which also serves the webapp holds the state of the Smart Shelf and has a mapping of these scanned ids to drawers and items. The different items contained in the shelf, the amount of them and current searches are called here as *state*.

As mentioned before an unsatisfying fact is, if the user search for a while for a specific item and finally find it, the drawer is empty. To address this problem the Smart Shelf provides a *predictive management system* (abbr. PMS). This PMS enables the system to send notifications to operators if a drawer is empty or almost empty. Notifications enables the operators to react early to items with low or zero amount. This decreases the chance of out of stock items. To realize such a PMS data are needed for analysis and reaction based on specific conditions. Every drawer will get a electronic unit to measure the weights of the items in a drawer. These measurements are send to the server, which calculates with the stored weight of the specific item, the amount of items in that drawer. This enables the PMS to have an overview of the state about all items contained in drawers. Additionally to notifications a visual feedback is given at the shelf itself. Empty drawers are marked with a red light to indicate this to users directly.

As mentioned before visual feedback is a central point in the design of the Smart Shelf. Therefore, it is used to indicate the searched drawer to the user and if a drawer is empty. However, the prototype uses visual feedback additionally for a so called *service mode*, which can be switched on and off. During service mode every drawer visualizes its state with different colours. Blue colour, if the drawer contains more items than a specified threshold. Yellow colour as warning, if there are less items than the threshold and a red colour, if there are zero items left. For this service mode the data acquired with the weight measurement are consulted.

## Visual Feedback Colours

### Assumptions

To realize this prototype some preconditions are assumed which are listed in this section.

All items in the shelf are either without packaging or with packaging. There will be no drawer where items are mixed. Furthermore, at any time there is only one sort of items in one drawer. Every drawer contains different items. The weight of a specific item is stored in the server for the amount calculation.

## IMPLEMENTATION

### EVALUATION

To evaluate interactive smart shelf, we tested it more than once time in real world scenarios. We find some strengths and weakness after the evaluation of our project. Moreover we done seven activities during evaluation that are listed in a below table.

#### Strength

- The design of drawers are reliable, long lasting and have Multiple User Interface.

- Color of LED'S follows cultural analogy, i.e. Red (no item), Blue (have an item) and Yellow ( $\leq$  half amount) in each drawer.
- If there isn't any item or have less than half amount of an items in drawers, send notification email to administrator.
- Web application smoothly start service mode that depicts the current state of smart shelf.
- More than one user can search items simultaneously.
- Using QR code user can get detail information of items i.e. capacity of resistors etc.

#### weakness

- Keep small circuit inside each drawer is not good idea. It became messy with items even LED'S inside drawer is not clearly visible for visualization.
- Most important keep a plastic plate on the top of load sensor to fix load sensor inside drawer does not give proper measurement.
- Power supply is also an issue, when multiple drawers connect with micro controller.
- Place a QR code outside of each small drawer is also a challenge.

#### Best Scenarios

The project works best when search any item in drawer and scan QR code to get further detail through web app. Although proper communication is established between web app and micro controller via MQTT protocol.

#### Failed Scenarios

Sometimes when service mode start/stop, LED'S are not properly ON/OFF because of inefficient power supply. Power supply for Arduino is crucial as it stop works at any random point of time in between of service mode which is not good. Further More load sensor does not show accurate weight of items owing to resistance in between plastic plate and drawer. A broken of MQTT connection immediately would lead to loss of communication between Micro controller and Web app.

#### User Testing

We tried web app Smart Shelf with different users and observe while they were doing these activities. These activities are listed in a given table below.

We tested all these activities with different 4 participants and get feedback about this web app. The participants were from different age groups range from 22 to 30 years old people some was employee and some were students. For each participant performed each activity 10 times as mention in table. Then we evaluated the number of successful observations, false results and no response. We calculated the percentage of successful observations for each activity and each participant perform these activities and reasons of fault results.

For activity 1 and 5, we found our system is working properly almost 99%. While for activity 2, the system was relatively less accurate as compared to the first activity. More than once time the system does not show perfect. In 81 percent cases the system measured the weight of items correctly but 19 percent the system failed to measure quantity of items. Because to calculate quantity was depend on accurate weight measurement but sometimes load sensor interpret wrong weight. That's why with 3rd participant the success rate was 81 percent as compared to the 2nd one. Meanwhile activity 6 had high percentage of correct cases with 99 percent among the other all activities. As we went further and test activity 4 and 5, achieved success ratio over 96 percent, 4 percent cases was failed because of incorrect operations performed by novel users. In Contrast the last activity, 55 percent cases was failed because of the system was behave unintentionally and inefficient power supply to micro controller was also a critical issue. So the result was not fine among all of above mention activities as 72 percent cases were failed because of inefficient power supply. Participants

give bad feedback when they stopped service mode the LED'S was still blinked and system became unresponsive. At the end we conclude overall success rate of our smart shelf web app in the light of these 7 activities was 90 percent was perfect as shown in fig (a). As this figure represent the overall evaluation report in form of chart. But 10 percent was unsatisfied owing to some reasons that is mention above.

## **FUTURE WORK**

### **CONCLUSION**

We have deployed the content of physical computing in the form of interactive smart shelf where user interact via web app and get visual feedback according to operation. Our main goal to design interactive smart shelf to reduce conscious thought while search an item as well as provide reliable and efficient way of searching , save time and provide multiple user interface. By using Ubiquitous and other technologies, interactive smart shelf enhance the usability of shelves.