Empowering Smarter Fitting Rooms with RFID Data Analytics

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Abstract. Smart Fitting Rooms offer great potential to enhance customer shopping experience in retail fashion stores. To this end, they leverage auto-id technology to detect product selections of customers and offer additional services based on these selections on screens within the Smart Fitting Room cabins (e.g., product recommendations or Omnichannel services). While current implementations mainly rely on hardware-based approaches to reliably detect customer's product selection, we investigate the applicability of software-based approaches to distinguish between products in individual cabins. In addition, we show that software-based approaches can be used to sort products in fitting rooms by relevance to the customer which is a valuable information for providing additional services.

Keywords: Data Analytics, RFID, Context Awareness, Internet of Things

1 Smart Fitting Room Opportunities

Internet of Things (IoT) technologies offer great opportunities to enhance customer shopping experience in retail fashion stores [1]. Such context-aware technologies have the potential to create pervasive retail systems that are able to accommodate user needs and wants when desired [2]. We consider Smart Fitting Rooms, which are an example of such context-aware environments. Such fitting rooms are not just cabins for trying on selected garments. Instead, they offer customers additional services on a screen within the cabin based on their product selection. Such services are for example (i) product recommendations or (ii) Omnichannel services.

Product recommendations facilitate cross- and up-selling and can lead to substantial sales increases for retailers [3]. Wong et al. [4], for example, provide such recommendations to customers in Smart Fitting Rooms at a fashion chain store in Hong Kong and find that they lead to sales improvements of more than 20%.

Omnichannel services, on the other hand, provide customers with a seamless shopping experience which can lead to a competitive advantage for retailers [5]. The smart fitting room offers various possibilities to bridge the gap between the different retail channels by, for example, offering customers to purchase products that are currently not available in the store from the online store in the Smart Fitting Room.

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2 Limitations of Current Implementations

Retailers have already started testing fitting rooms that offer additional services to customers. While some of these retailers provide customers with barcode scanners for the identification of items, others rely on Radio Frequency Identification (RFID) technology. RFID uses electromagnetic fields to automatically identify and track tags that are attached to objects. The technology is already commonly used in the retail supply chains for the automatic detection of logistical units in upstream and backroom processes. In contrast to optical barcode scanning, RFID tags not only enable the detection of the amount of items belonging to a specific product category but also permit the identification of each specific item. Moreover, RFID-based object identification does not require a direct line of sight between the tag and the reader device and thus allows for simultaneous bulk detection of multiple objects.

Thiesse et al. [6], Melià-Seguí et al. [7], and Wong et al. [4] describe pilot projects with Smart Fitting Rooms that rely on RFID technology. The application of RFID for such processes is, however, error-prone and challenging [8]. This is because in contrast to controlled processes in other parts of the supply chain, the sheer number and variety of simultaneously moving objects is very high. Complexity is further increased by the manner in which objects are transported, unpredictable customer walking paths, and suboptimal store layouts. To cope with these challenges, existing implementations mainly rely on hardware-based approaches. These approaches require the installation of one RFID reader system for each cabin and the use of shielding measures (e.g., shielding paint, thick fitting room walls from floor to ceiling) to ensure that only objects within the cabins are detected by the RFID systems. Another drawback of current implementations is that they are only able to detect all products within them but cannot distinguish between relevant products (e.g., products that are currently tried on) and others (e.g., products that hang on a coat hook). It is obvious that such information would be valuable for retailers as this would, for example, allow them to display only recommendations for items that customers are currently interested in.

3 Description of the Smart Fitting Room Artifact

We investigate the applicability of software-based approaches to tackle the previously mentioned limitations of current implementations. To this end, we follow the guidelines put forward by Hevner et al. [13] and develop an artifact that (i) detects garments within cabins without using shielding measures and (ii) sorts them by relevance to customers. Our current experimental setup considers three fitting room cabins (Figure 1).

The architecture of the artifact combines hardware and software components. The hardware component is a sensor infrastructure that collects sensor data that is then processed by the software components. We propose the use of a ceiling-mounted RFID system with a reader device and an antenna array with 52 far-field antenna beams which are mounted in one housing. Table 1 provides an exemplary data excerpt from the raw data gathered with the reader installation. Each row reflects a single tag read event triggered by one of the reader's antennas. Here, EPC is the unique identifier of the RFID tag, RSSI is the radio signal's power measured in dBm, Doppler is the frequency shift of the received signal at the reader due to relative motion between the reader and the tag, and Antenna is the ID of the antenna that read the tag.

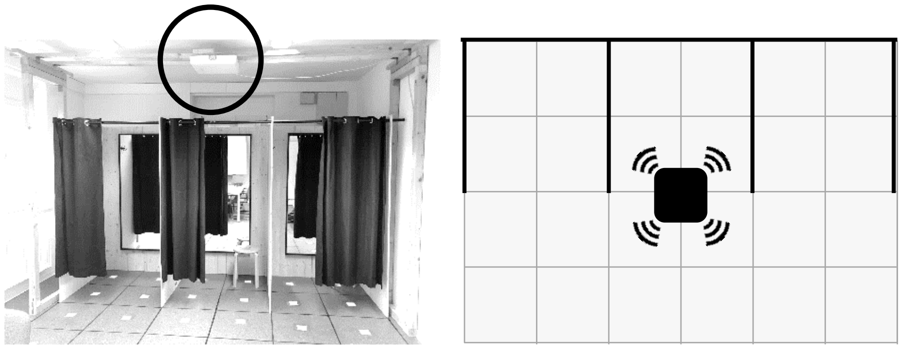

Figure 1. Test environment with ceiling-mounted RFID system and three fitting room cabins

Table 1. Exemplary data excerpt

EPC	*Timestamp*	*RSSI*	*Doppler*	*Frequency*	*Power*	*Antenna*
E28011606…	1465992659	-66.0	25.187	867.5	30.0	51
E28011606…	1465992660	-64.0	30.875	867.5	30.0	2

The first software component combines supervised machine learning and probabilistic models to detect items in individual cabins based on the low-level RFID data collected by the hardware component. In a first step, we determine the positions of tagged items using the indoor positioning technique “Scene Analysis”, which estimates the position of objects by matching their real-time measurements with “fingerprints” at different positions [9]. To this end, we apply multiclass classification techniques which necessitate dividing the fitting room area into grid fields and collecting training data for each of these fields. Here, the number of grid fields denotes the number of classes considered in the data mining model. In a second step, we consider the layout of the fitting room area and characteristics of the processes in fitting rooms to improve the positioning accuracy. The former comprises for example information about the location of fitting room walls, the latter builds on the assumption that some sequences of item locations within a certain time period are more likely than others.

The second software component relies on supervised machine learning techniques to sort garments in fitting rooms (i.e., the garments detected by the first software component) by relevance. To this end, we extract features from the raw data, which contain information regarding observed real-world events. The considered features are appropriately specific to RFID and must be developed based on knowledge of the particular business process. Examples are the number of tag reads, the standard deviation of the RSSI values, or the median of the Doppler frequency shifts of a particular tag within a certain time interval.

4 Expected Contribution and Future Work

Our initial study shows that current limitations of existing implementations can be tackled with software-based approaches. Our artifact is able to detect products in cabins (without the need of shielding measures) and sort these by relevance to the customer. Going forward, we want to evaluate our artifact in different test environments. Here, we want to focus on complex settings, such as high numbers of customers and products in reading range of the antennas or different customer movement speeds. Although first results are promising, we expect that additional tests will introduce new challenges. Our ultimate objective is to ensure feasibility of our approach under real-world conditions.

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