Enhance shopping experience and support decision making leveraging BLE beacons in a grocery retail store

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Abstract

In response to shoppers' increasingly high expectations of their in-store experiences, retailers have developed an interest in recent technological developments, including the emergence of the Internet of Things (IoT) and smart technologies. Among new sources of information that are consequently becoming available to retailers, is the location of a shopper inside the store, provided by indoor positioning systems (IPS). This paper aims to connect previous research, which is often focused on either the technical or practical aspects of such systems, but not both. We present the case of an IPS based on Bluetooth beacons, deployed and tested at a grocery store, and discuss industry-specific ways in which the contextual information collected can be utilized to enhance in-store experience and improve retail performance.

Keywords: Indoor positioning, BLE beacons, Shopping experience

1. Introduction

The concept of the shopping experience has always been of crucial importance to the retail industry. However, over the last decade, its perceived impact in consumer behavior and retail performance seems to have been brought into the foreground. The shopper decision process has grown remarkably complex (Puccinelli et al., 2009), while other experience-related factors, such as consumer gratitude (Huang, 2015) and consumer comfort (Ainsworth & Foster, 2017), have also been known to play a role. Shopper journey has evolved into a combination of multifaceted experiences (Grewal, Levy, & Kumar, 2009), as a result of socioeconomic change and technological breakthrough. This has been particularly true in grocery retail, where, even with the growth of ecommerce, in-store shopping experience has emerged again as an integral and increasingly sophisticated part of shopping behavior (Esbjerg et al., 2012; Maggioni, 2016). As shoppers moved from merely consuming goods to seeking meaningful experiences, retailers became increasingly interested in latest technologies and innovation (Pantano, Priporas, Sorace, & Iazzolino, 2017). Business analytics techniques revealed additional ways to discover shopper insights (Shankar, Inman, Mantrala, Kelley, & Rizley, 2011), enabling innovations in pricing and promotions (Grewal et al., 2011), new retail business models (Sorescu, Frambach, Singh, Rangaswamy, & Bridges, 2011) and omnichannel retailing (Verhoef, Kannan, & Inman, 2015). Recent advancements have led the industry to more experience-oriented approaches, employing innovative mobile technologies (Pantano & Priporas, 2016) and artificial intelligence (Dirican, 2015). Apart from technological competition, there is also a considerable amount of pressure on retailers from newer generations of shoppers, who seem to be looking for new ways of engagement (Accenture, 2017) and better shopping value as a result of further retail innovations (Priporas, Stylos, & Fotiadis, 2017). Therefore, while not all of these technologies have been widely established, the industry is rapidly evolving and will be called to immediately embrace further advancements in the near future (Grewal, 2017).

Among the latest technological developments to capture the interest of the retail industry is the emergence of the Internet of Things (IoT), proposing that different machines and devices should be able to connect to and interact with each other (Lee & Lee, 2015). The potential to enhance the shopping experience by using smart devices, such as smartphones and wearables, in a smart environmental context, involving sensors, personal shopping assistants, in-store automation or augmented reality, has supported new concepts, such as mobile shopper marketing (Shankar et al., 2016) and smart retailing (Pantano & Timmermans, 2014). These smart technologies can be used to improve perceived shopping value in terms of both enjoyment (Pantano & Naccarato, 2010) and utilitarian benefits (Willems, Smolders, Brengman, Luyten, & Schöning, 2016).

IoT technologies, not only can provide retailers with new tools to support different actions based on current knowledge, but can also help create new sources of information to expand academic and business understanding of shopping behavior. Among these new sources is the location and flow of shoppers inside the store. Information about shopping trips has been available through empirical research, but there has been a lack of quantitative data to validate the results of such methodologies (Sorensen et al., 2017).

IoT can be employed to fill this gap in the form of indoor positioning systems (IPS), which can be used to determine the location of an object inside a building. While there have been many implementations of IPS in the literature, discussion of their practical implications for retail has been limited. Applications of in-store localization have been often explored as a small part of IoT, in a rather abstract and not always industry-specific manner. In an attempt to bridge the gap between technical implementations of IPS and empirical studies of their value for the retail industry, we present the case of an IPS that was deployed at a typical store of a Greek grocery retailer to track shoppers throughout their shopping visit, and discuss different ways that retailers could utilize this information to enrich shopper insights and improve retail experience.

2. Background

Location-based services (LBS) are generally defined as services that integrate a mobile device's location or position with other information so as to provide added value to the user (Schiller & Voisard, 2004). Related applications have been present since the introduction of the Global Positioning System (GPS) in 1978, yet LBS as an academic field of study became prominent only in the late 1990s. Evolution and expansion of mobile technologies has led to the concept been redefined and re-evaluated several times since (Junglas & Watson, 2008; Schiller & Voisard, 2004). Earlier scholarly work has explored the potential of such systems (Rao & Minakakis, 2003), but actual implementations and practical implications have not been discussed until recently (Y. Liu & Wilde, 2011). While outdoor location services evolved relatively fast, indoor localization has not been widely available until recently (Gressmann, Klimek, & Turau, 2010) and full-scale applications have yet to be introduced to the general public.

Determining the position of an object is not always necessary in order to provide location-specific context, but the resulting information can be manipulated and utilized in different problems easier than in alternative approaches, such as proximity sensing. Systems that can determine the location of an object in indoor environments are called indoor positioning systems (IPS) (MacAgnano, Destino, & Abreu, 2014). Traditional technologies available to IPS include RFID, UWB, Wi-Fi and Bluetooth (H. Liu, Darabi, Banerjee, & Liu, 2007), while more recent approaches have employed cameras (Wu, Wang, Chang, & Chou, 2015) or LED lighting (Guan et al., 2017; Vieira, Vieira, Louro, Mateus, & Vieira, 2016). While there are many IPS examples available in literature, only a limited number of such systems have been tested in real-world contexts and evaluated on their practical impact.

Most of the related cases in this context of the retail industry focus on shopping path analysis. Among early examples, Larson, Bradlow, & Fader (2005) use shopping path data from an RFID-based IPS presented by Sorensen (2003), who placed tags on shopping carts and installed readers on different locations of a grocery store. Data mining is applied to the dataset provided by a company in order to produce path clusters. More recently, Sturari et al. (2016) develop an IPS based on Bluetooth beacons with a similar purpose. Path patterns are discovered from a visual representation of the data. Wu et al., (2015) present an IPS that extracts patterns from

images of the store. The aforementioned studies concentrate on developing a methodology for handling such datasets, but do not extend the analysis with a view to support decision making. While IPS-specific literature has focused on shopping path analysis, other ways retailers could utilize this information have been extensively discussed as part of recent IoT technologies. Pantano & Naccarato (2010) refer to personal shopping assistants, while Shankar et al. (2016), and Lee & Lee (2015), considering location-based services among mobile shopper marketing technologies, point to contextual coupons and personalized offers. Grewal, Roggeveen, & Nordfält (2017) view location-specific information as a new big data source that can be analyzed to provide new shopper insights and improve customer experiences.
A review of the literature reveals a lack of practical implementations of IPS systems that could facilitate decision making, enhance shopping experience and establish a comprehensive discussion of the value such systems could create for the retail industry. The purpose of this paper is to fill this gap by providing such a case and laying the basis for more practical approaches in future research.

3. *Case Study: Placing BLE beacons in a grocery retail store*

The indoor positioning system presented in this paper was developed as part of a location-based service designed along with a major Greek retail chain. Bluetooth Low Energy (BLE) was selected to support the IPS, due to limitations of the grocery store provided for the field experiment. BLE technology was also easy to integrate with mobile apps, using one of many commercial SDKs available.

3.1. Generated dataset

A Bluetooth beacon is a power efficient radio transmitter that broadcasts a unique identifier along with location-specific data. This radio signal can be tracked by nearby Bluetooth enabled devices and used to provide an estimate of the distance between the beacon and the tracking device, based on received signal strength (RSSI). In our case, a customized mobile app, running on the shopper’s personal device, scans for the signal of nearby beacons and records the ones closest to the shopper. This process is repeated every few seconds, producing a series of beacon tracking events, associated with a single shopper and the timestamp of the event. The format of the data produced is presented in Figure 1. The emerging challenge is to use these unprocessed data to determine an approximate location of the shopper inside the store.


```
{
    “beacons”: [{
        “id”: “1780d99d-10e6-4223-b79d-aacf78ad58a3”,
        “distance”: 1.71
     }, {
        “id”: “29ab587e-2baf-4fa7-a188-cfe6551585e0”,
        “distance”: 2.34
     }, {
        “id”: “b9dbc735-ebf7-441b-91d2-1db113318cfa”,
        “distance”: 4.88
     }
     ],
     “time”: “2017-03-16 18:44:56:126”
}, {
    “beacons”: [{
        “id”: “1780d99d-10e6-4223-b79d-aacf78ad58a3”,
        “distance”: 1.96
     }, {
        “id”: “29ab587e-2baf-4fa7-a188-cfe6551585e0”,
        “distance”: 2.03
     }, {
        “id”: “2c312f76-c9c0-4ffc-ad30-36f391abd7be”,
        “distance”: 3.86
     }
     ],
     “time”: “2017-03-16 18:44:58:217”
}
```


Figure 1: Sample beacon tracking events in JSON format.

3.2. Implementation challenges and proposed beacon layout

The setting of the typical grocery store selected to host the field experiment proved particularly challenging. Contrary to similar cases in recent scholarly work, where experiments were conducted in labs or relatively smaller showrooms, the size of the store required that beacons should be placed not only on the perimeter of the store, but also in intermediate areas, where a suitable position was not always available. The store consisted of two floors, leading to altitude-related issues and signal interferences. Moreover, Bluetooth signal was often intercepted by intervening products and store equipment of different materials, suggesting that the produced data involved a considerable amount of noise and measurement inaccuracies. Wireless networks and shopper-owned devices were occasionally accountable for further signal interference, especially during store peak periods.

To address these challenges, beacons were placed on the ceiling of each floor, and additional intelligence was included in the mobile app to help determine on which floor the shopper was located. The eventually proposed layout consisted of 90 beacons, arranged in a way that resembled a grid and divided each floor into smaller areas (Figure 2). Each of these areas was associated with a unique and meaningful set of product categories. Preliminary alpha and beta testing using different mobile devices was iteratively conducted, in order to validate the layout and produce datasets for the indoor positioning approach.

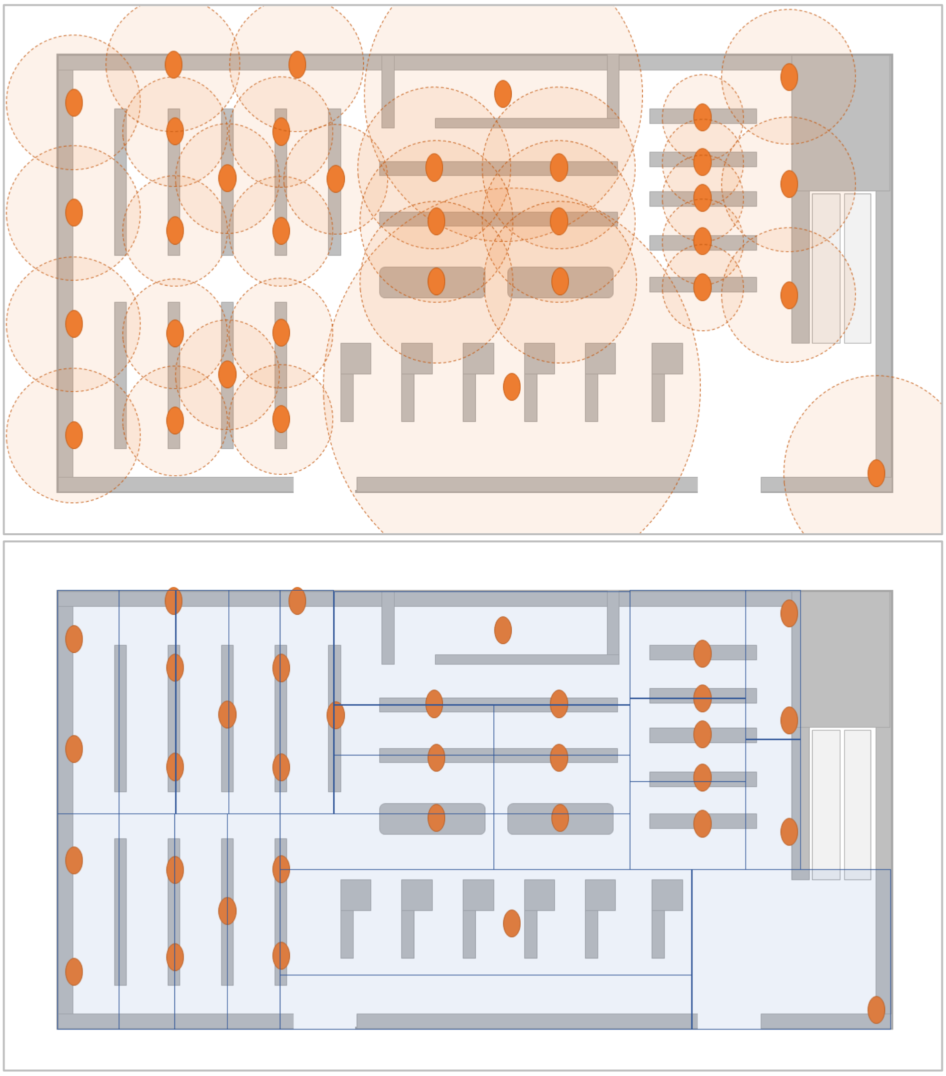

Figure 2: Proposed beacon layout and subsequent subarea division.

3.3. Developing the positioning model

In order to utilize the data provided by the mobile app, a model that could use these spatiotemporal events to determine the location of the shopper was to be developed. A straightforward solution to this problem would be to use trilateration. According to this approach, the measured distances of the beacons closest to the mobile device could be used to calculate the location of the shopper in relation to these beacons. Since the absolute positions of beacons are already known, one could easily track the shopper's absolute location inside the store. For this approach to be effective, it is required that these measurements are accurate or, at least, comparably inaccurate. As previously mentioned, however, in the real context of the particular grocery store, the data collected were excessively noisy for such algorithms to produce reliable results.

An alternative approach that could offset the accuracy issues was proposed. Instead of calculating the exact position of a shopper inside the store, one could attempt to determine the surrounding area. The model was altered to employ fingerprinting and machine learning algorithms. This revised model identifies similarities between already located spatiotemporal events and new beacon tracking data in order to predict in which area of the store each newly collected event is most likely to originate. The approach is still being tested, but trials have yielded promising results so far.

4. Decision Support

Nowadays, since retailers are facing stiff competition, understanding shoppers and enhancing their in-store shopping experience is vital for profitability. Having stored large amounts of data, such as in-store shopping paths, valuable knowledge can be obtained to support data-driven decision making. In our case, the mobile app could help shoppers navigate the store and find desired products. It could also enhance proximity marketing delivering customized messages, location-based advertisements and content. In the same spirit in could be also used to identify shopper's location. This way we could generate heatmaps regarding the areas that the shoppers spend the most time while they are shopping. This way marketers and store managers could gain powerful insights to design effective marketing actions and in-store advertisements, or even to identify selling gaps by monitoring the areas that shoppers spend a lot of time, but finally they don't purchase products displayed in these areas.

Moreover, by exploiting the generated data from an approach like this, the retailer had the opportunity to obtain valuable knowledge for their customer's paths. First of all, with an easy and visual way, the retailer could be able to discover which product categories cause consumer interest and bring profit to their businesses. Knowing that customers spent a lot of time at a specific store area, they can assume and study a number of business issues. Comparing geospatial data with actual sales through POS data, the retailer could find selling gaps and thus adjust the demand making various promotions to reduce the unmet market. Also, possessing the knowledge of the most prosperity categories, was retailer's discretion to boost the sales of other categories with less consumer interest. Such information can form the basis for monitoring the product assortment through the category management and volume controlling.

Knowing at which parts of the store's aisles there is higher or lower customer volume, retailer could be able to support decisions according to location experience. This ability could be supported by the use of the visualization tool, in which areas with high volume were depicted with warmer colors while areas with lower volume were depicted with colder colors, as shown in Figure 3. The metric of volume had two different representations, one of customer as an entity and one of their time that they remained in an area. With the aid of this visual information, retailer could be set to gain insights and thus to support a territorial reform according to the customer traffic and their travel time. Moreover, valuable suggestions for the adjustment of product or aisle alignment may arise, so either to facilitate the consumer's journey or customers disperse in as much more areas is possible.

Figure 3: Screenshot of a heatmap from the visualization tool.

Additionally, discovering shopper patterns and motifs, retailer could improve and personalized their shopping experience. With the use of a location-based customer tracker, retailer could have the opportunity to approach their customers through their mobile devices and thus, according to their geographical locations promote them personalized messages and shopping offers. Combining this information with demographic and personal data such as name, date of birth etc., the customer's approach could become even more personalized and holistic. As a result, the customer satisfaction and the level of service will be increase, as well as the awareness and reputation of the retailer and their shops. Eventually, customer fulfillment could boost positive behavioral attitudes and referred as one of the best means of advertising.

5. Conclusion

The emergence of the Internet of Things and smart technologies has created new opportunities for retailers. As shoppers demand better shopping value, there is an increasing need for new concepts. Location-based services and indoor positioning systems can supply retailers with new tools and insights in order to provide high-quality shopping experiences and improve retail performance. We present a case in which such a tool was developed and deployed in a grocery store, aiming to discover location-specific shopping patterns. We also discuss different ways in which such knowledge can be of use to retailers, such as identifying selling gaps, improving store layout and offering personalized services.

While research either focusing on the technical aspects of IPS or exploring the value of localization technologies for different industries has been previously available in literature, there is a lack of business-oriented IPS cases, discussed from both a technical and practical point of view, that can serve to discuss business implications in a specific context. We address this issue, acknowledging a need for industry-specific insights into such technologies and attempting to bridge the gap between technical and empirical work on that matter.

We provide retailers with basic insight on how to deploy a location-based service and discuss practical value of such systems, hoping to encourage similar cases in the industry. There is great potential for localization technologies particularly in grocery retail, because of the large number and high differentiation of products and consumers. We also hope that such a case can encourage retailers to approach researchers, enabling an alignment of academic development of such systems with an industry understanding of their value.

In this paper, we propose some ways in which contextual information provided by IPS can be practically applied by retailers. This work could be extended by providing a more detailed discussion of such applications, including implementation challenges and results. The shopper perspective, as well as ways shoppers and retailers interact in such systems, could also be further explored. Finally, future research could address retail-specific issues regarding acceptability and scalability of IPS systems.

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