

Participatory Sensing for Fighting Food Deserts

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ABSTRACT

We present a participatory sensing system, which collects food availability information in communities via individual food consumption information, for fighting food deserts. Users leverage the NutriSmart Android app developed to record food purchases and consumption choices. This information can then be aggregated and mapped across users. The results of the system can be used to lobby for change in schools and communities, where lack of accessibility to fresh food choices limits healthy choices that individuals make. The system, the implementation, and the results of a 3-week case study in San Jose are presented.

General Terms

Design, Human Factors.

Keywords

Participatory sensing, urban sensing, mobile computing, obesity, public health.

1. INTRODUCTION

We present a participatory sensing system to address the lack of healthy and fresh food choices in communities classified as “food deserts”, by collecting data as evidence to affect policy changes.

There is growing evidence that obesity prevention efforts require supportive home, neighborhood, school, and work environments. Indeed, the American Academy of Pediatrics acknowledged the need to engage in public advocacy, to convince school boards of the importance of healthy school food choices and to urge local grocery stores to offer low-cost, healthy food [1]. The American Heart Association also has issued a statement [2] indicating that the solution to the obesity epidemic lays in the social, environmental, and policy influences. The California Center for Public Health Advocacy demonstrated the power of using community-level data with the Los Angeles City Council’s approval of a one-year moratorium on the licensing of new fast food restaurants in south Los Angeles. [3]

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Our NutriSmart system leverages an Android application that allows users to log where they are purchasing food, as well as the types of food they are consuming. With the aggregation of this data across neighborhoods, the database can show problematic regions in our communities. The system will highlight the areas with a high concentration of fast food restaurants, as well as those with a lack of grocery stores or access to fresh produce.

People who have good knowledge of healthy eating habits may be prevented from acting on that knowledge due to their location and the lack of access to nutritious food. This application will enable users to identify food products in schools, work place cafeterias, vending machines that have the potential to increase risks for health-related diseases. Armed with this knowledge in aggregate, parents of school children and employees can lobby for improved nutrition offerings, and communities as a whole can petition for the construction of healthier restaurants and additional grocery stores, eliminating “food deserts”.

We conducted a case study of the NutriSmart system, over a three-week period in the San Jose area. The results of the study reveal differences witnessed across four different commercial establishments.

2. RELATED WORK

Participatory sensing involves networks of everyday mobile devices being leveraged by users for the collection and sharing of data [4]. Researchers have developed and demonstrated the power of participatory sensing systems for various applications. Examples include systems developed for tracking bike lanes and bike safety on the road [5], for bargain hunting [6], and for monitoring carbon monoxide and noise levels in campsites [7]. Here, we use participatory sensing for creating food availability maps for communities, explicitly for the purpose of improving the availability of healthy food options.

Apps for monitoring food intake are numerous. For example, Dorman et al demonstrated the benefit of looking up USDA health data for food was beneficial for behavioral cuing of individuals [8]. Many commercial apps for calorie counting exist for Android and iPhone smart phones, as well. Our system, however, is not intended for counting calories, but is intended to determine food availability information, based on individual food purchase patterns.

The tracking of grocery store receipt information has been found helpful for identifying healthful and less healthful dietary patterns, so the practical benefit of a nutrition analysis of the patient’s weekly grocery basket has already been demonstrated [9].

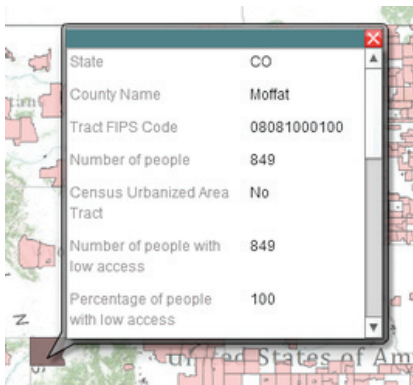


Figure 1 | The USDA food desert mapping tool provides other insightful information about food desert regions, including population, county, and percentage of people with low access to healthy food.

A related tool is the USDA’s map of food deserts pictured in Figure 1. This map shows that approximately 13.5 million people living in the regions where the data was collected from have limited access to fresh and healthy food. 10% of the 65,000 census tracts were determined to be food deserts. The results of our system can be used for more fine-grained and complete data collection, incorporating the subtle influences of safety, store hours, and cultural preferences.

3. SYSTEM OVERVIEW

Our system relies on participants collecting individual data, which can then be aggregated across users in the same community, be it a neighborhood, a workplace, or a school. To enable the fast and convenient collection of data, the NutriSmart app was developed for the Android platform. To incentivize usage, tracking of calorie information was provided for individuals.

NutriSmart is currently tailored for grocery stores and restaurants. The functionality of the NutriSmart system can be divided into two subparts: data collection—which differs between restaurants and grocery stores, and data mapping.

- Data Collection (Grocery Stores):** In this first step, the user manually inputs relevant information including store name and quantities of each food group purchased while the app automatically stores the GPS coordinates of the store. The app recognizes five general food groups: grains, vegetables/fruit, dairy, meat/beans, and junk food. Popular food items have already been pre-entered into the app’s central food database, which takes care of classifying food items into their respective food groups. While users are shopping, the default “Shopping Cart Input” screen prompts them with a text field where they can enter the name of the food product that they are buying. The text field auto-fills in based on appropriate matches against the app’s food database. If the food item is not in the database, or if the user does not agree with the food group placement of the item, they can override the default decision by manually selecting their preferred food group, as shown in Figure 2b. This food item will then be added to the central database under the user-preferred food group for future use. In both cases, the quantity of each food group is calculated based on user input of the number of calories per serving and the total number of servings in the food item. This data is then displayed on the “View Cart” screen that shows the percent quantities of each food group calculated based

on the total number of calories in the cart. Once the user finalizes his/her shopping cart and checks out of the shopping cart tool, the data from that shopping trip gets saved to a database to be used later for mapping purposes. Selected screen shots of the grocery store data collection portion of the app are shown in Figure 2.

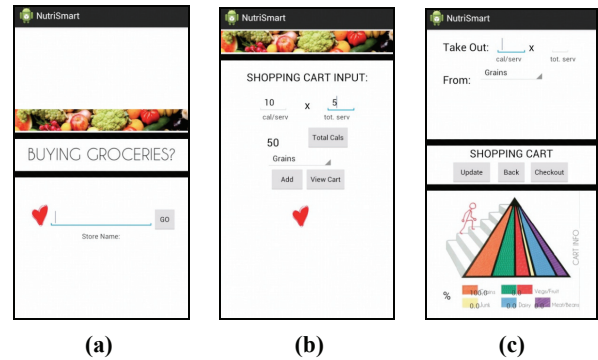


Figure 2 | a) First screen prompting user to enter name of the store. b) One of the shopping cart input tools of the application. Users manually add to specific food groups by indicating calories per serving and total number of servings in that food item. The “Total Cals” button will then calculate the total number of calories in that item. The user can then use the drop-down menu to select which food group these calories should get added to and push the “Add” button to process the information. c) This displays the current food group quantities of the user’s shopping cart. Users can modify its contents as well.

- Data Collection (Restaurants):** Because restaurants often have a wide range of food items, it is hard to classify a restaurant as healthy or non-healthy based on the food that the user decides to consume there. For example, if a user were to eat a salad at McDonald’s versus a Meatball Sub from Subway, food consumption alone would classify McDonald’s as the healthier restaurant, which from an overall standpoint, is not true. Thus, a 5-point rating system is used to gather the user’s personal opinion of the restaurant. This can be seen in Figure 3. Although this method factors in significant personal bias, aggregated data over users of a local community will be able to provide insightful information regarding how the users perceive the restaurants in their vicinity. The ratings will be averaged out to achieve a more balanced rating, representative of the opinions of the community.

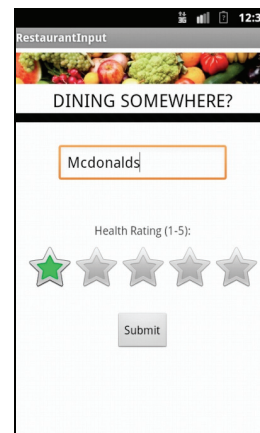


Figure 3 | Data collection for restaurants. Users input the name of the restaurant and give it a health rating on a scale of 1-5 where 1 is the most unhealthy and 5 is the most healthy.

- Data Mapping:** This step uses information accumulated from the data collection process and transforms this stored data into a graphical representation on a map. This map displays the user’s “history”—showing all locations the user has logged as a food source. The map starts off zoomed in on the user’s home location, where a home icon will appear. The two buttons labeled “Dine” and “Shop” at the top of the screen will allow users to see all restaurants and grocery stores, respectively, that they have visited. A third button labeled “Find Me” will animate the map to the user’s current location. On tapping a restaurant icon on the map, the user will be able to see the name of the restaurant as well as their health rating of that restaurant. On tapping a grocery store icon, the user will be able to see the name of the grocery store as well as all food group quantities he/she has purchased there, based on total number of purchased calories. Problematic grocery stores where junk food purchases surpass 50% are shown as a crossed-out icon. This interface can be seen in Figure 4. With enough location points, the user may come to realize, for example, that they purchase significantly higher quantities of junk food at certain stores compared to others. Even though an individual’s data is biased towards personal preference, aggregated data over all users of the app can reveal insightful information about food deserts within a local community. Indeed, if people are not buying or consuming healthy foods in a certain neighborhood en masse, it is highly likely that they do not have access to healthy food choices.

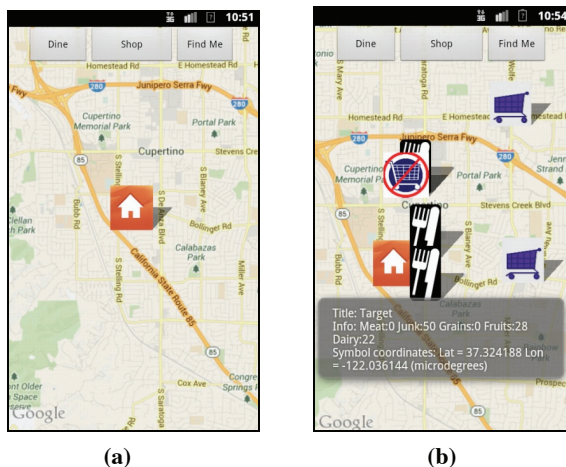


Figure 4 | a) Initial display of the history screen, zoomed in to the location of the user’s home (used as a reference point) b) Upon clicking both the “Dine” and “Shop” buttons, the following display is achieved. Restaurants are indicated with a fork/knife icon and grocery stores are indicated with a shopping cart icon. Upon tapping on an icon, a Toast widget pops up indicating the store information.

4. IMPLEMENTATION

The back-end implementation involves two major components, directly paralleling the system’s functionality. The first component deals with storing the user’s shopping and restaurant data. Upon every “Checkout” or “Submit” button press, the finalized data holding information about the restaurant or grocery store gets stored as an entry to a SQLite database. Restaurants

and grocery store information are stored in two separate tables within the database. For a grocery store entry, the following nine data values will be stored: date, store name, longitude, latitude, and the calorie quantities of the five food groups. For a restaurant entry, two pieces of information get stored: the restaurant name, and the user’s health rating for that restaurant. The longitude and latitude coordinates are retrieved using Google Maps API, based on the assumption that the user will still be in the store.

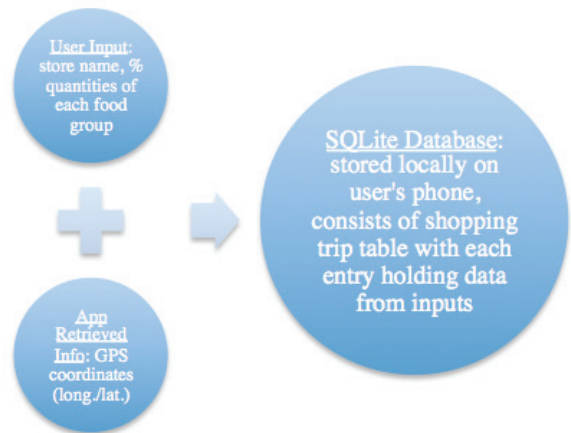


Figure 5 | Diagram representing the source and flow of data in the data collection process of the NutriSmart system

Once the data has been collected, the mapping process transfers these data points (entries in the database) to a map based on the longitude/latitude coordinates of the entries. Each unique longitude/latitude pair of coordinates corresponds to a unique GeoPoint representing the store/restaurant location. In order to handle the “on tap” events where the user taps on a data point, the Toast widget was used for the displaying of the textbox containing all relevant information to that data point, as seen in Figure 4.

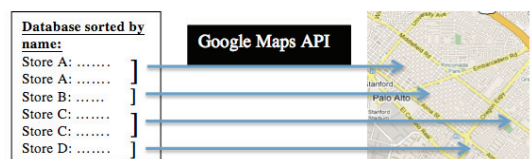


Figure 6 | Process of transferring data from SQLite database to graphical representation using Google Maps API. Data points are plotted using the longitude/latitude information stored with each entry. Database entries are sorted by name, and the data values get averaged out over all entries for a particular store.

This “history” map display is visible on the user’s own phone—containing only their individual data. However, this application will be expanded to upload all users’ information to a web server, which then updates a map accordingly. As mentioned previously, this larger map representation will be able to more accurately portray food desert regions across different communities. This can be achieved using an Android -> PHP -> MySQL scheme. HTTP protocol will be used to make the connection to the PHP script. The transferring of information from the phone to the web server will employ JSON (JavaScript Object Notation). NutriSmart will connect the device to PHP script every time the user finishes a shopping trip. Thus, at the same time the user’s data gets stored in the local SQLite database on their phone, a copy of that data will also get sent to the web server. The PHP script on the server will then connect to a separate SQL database, input the data, and

refresh the map display accordingly after taking the new data into account.



Figure 7 | Interfacing between the android device and PHP script that allows for all users' information to be displayed on a collective map.

5. CASE STUDY

In order to sample what kinds of information and patterns could be generated using this app, one user (female, regular grocery shopper) collected data using the app over the course of 3 weeks. The user frequented 4 stores on a regular basis during this time period: Costco, Target, Safeway, and 99 Ranch. Her shopping data in terms of percentages of each food group was plotted over all four stores, and the resulting chart is shown below.

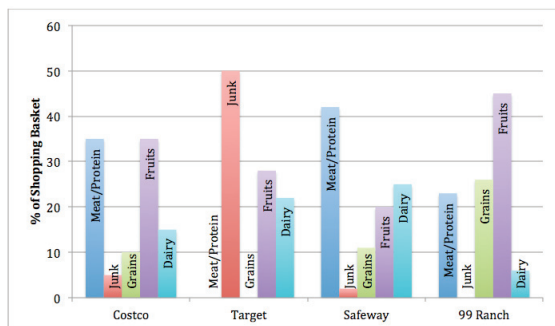


Figure 8 | Results from a 3-week period. The percent quantity of each food group is plotted across all four stores that were visited.

The data gives us some interesting information about the shopping habits of this user. Junk food makes up about 50% of the shopping cart when the user shops at Target. On the other hand, junk food purchases at all the other stores account for less than 10%. Using the map view display of this data, we can actually see that Target is relatively closer to the user's home compared to the other stores. The distances of all four stores are shown in Table 1. Although all of these stores can still be considered in reasonable vicinity of the user's house, it is still interesting to note that the closest store, Target, has the highest percentage of junk food purchases. Thus, in other neighborhoods, this system could indicate areas where there is a lack of accessible fresh/healthy food, and hopefully prompt affected communities to act accordingly.

Table 1 | Distances in miles of the stores (relative to the user's home)

	Costco	Target	Safeway	99 Ranch
Distance (mi)	7.3	1.6	1.8	3.4

6. CONCLUSION

A participatory sensing application was presented for aggregating food consumption information across different users in a community. As previously mentioned, even though on a micro scale, personal preferences regarding food consumption and restaurant choices may vary, on a macro scale, the system's aggregated data has the potential to reveal important information about the availability of healthy food around a local community. Armed with data demonstrating the lack of healthy food options, community members can petition for the construction of healthier food sources around their neighborhood. A case study using the system was carried out over a three-week period, whose results demonstrate the power of the system and the usability of the enabling Android app.

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