TaPuMa: Tangible Public Map for Information Acquirement through the Things We Carry

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ABSTRACT

The vast improvement in classical methods of information access and information retrieval has resulted from the invention of keyword-based search mechanism. Keywords serve as filters for desired information when users search in structured knowledge bases or with search engines such as Yahoo! or Google. In this paper we introduce TaPuMa, a Tangible Public Map, which allows people to use their own belongings, the objects they usually carry with them to access relevant, just-in-time information and to find locations of places or people from a public map. The paper also outlines and analyzes the advantages and challenges of this novel interaction mechanism, where real life objects serve as interfaces for information acquirement. At the end of the paper we briefly discuss the broad concept behind the project TaPuMa, 'Object Amelioration', where the functions of everyday objects can be expanded by using their affordances or functionalities in a variety of different contexts.

Categories and Subject Descriptors

H.5.2 **[Information Interfaces and Presentation]**: User Interfaces - *Graphical user interfaces, Input devices and strategies, Interaction styles.*

General Terms

Design, Human Factors.

Keywords

Tangible Public Map, Tangible User Interfaces, Interactive Environments, Just-in-time Information, Object Amelioration, Public Map, Real-life Objects, Information Acquirement.

1. INTRODUCTION

Maps are wonderful tools that help us orient and guide ourselves on a street, in a city, in a country, or on the planet. Maps are universal medium for communication, easily understood and appreciated by most people, regardless of language or culture. Incorporated in a map is the understanding that it is a 'snapshot' of an idea, a single picture, and a selection of concepts from a constantly changing database of spatial information. The map is one of the oldest forms of nonverbal communication. Humans were probably drawing maps before they were writing texts. As far as historians and geographers can determine, every culture in every part of the world uses and makes maps. This deep lineage reflects the descriptive usefulness of a map—a map is one of the best proofs that 'a picture is worth a thousand words.'

In the digital world, the central tenet of classical information retrieval mechanisms was that the user is driven by hierarchical information navigation. Internet search engines have popularized the keyword-based search paradigm. Broder[2] identifies three different types of web search: *navigational*, *informational*, and *transactional*. It has noticed that the intent behind a search is often not informational (what is the solar system), it might be navigational (how I can get there, where is the restroom) or transactional (guide me to the places where I can perform a certain transaction, e.g., buy a coffee, or use a service). Assuming an information need as the basis for an information search, Morrison, Pirolli and Card [8] focus on the activities that significantly affect the actions people take and the decisions they make. They classify these according to the variables- *purpose*, *method*, and *content*. An information seeker has some query in mind and with the use of keywords he interacts with the system to obtain the information he is looking for. Keywords or phrases are used to construct a search statement and eventually to find information. When a user types a word or phrase into the search field, the search engine tries to find an internet page that best matches the request. For example if someone was looking for information about history of Pyramids, they would probably enter "Pyramids" or "history of Pyramids" as their keywords. Google and the other search engines scour millions of pages on the web to find the handful of pages that best match this specific request.

In physical world, to search things, places and people, we are looking for, we use a different process. We use properties and characteristics of objects and places to locate and differentiate them among other objects and environment in the real world. In the digital realm, we rely heavily on words; in the physical environment, size, shape, color, and location set objects apart. We relate objects to their actions and places where we can perform those actions. ATM cards map in our mind to an act of transaction or buying and we relate them in our mind to places like bank, ATM machines, and stores. It is exciting to have so many information sources at our disposal, but the complexity of the environment demands new kinds of literacy. There is no

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analog of the simple keyword-based search systems that use everyday physical objects as keywords. We are interested in how people use maps [1]; how people find places and information they look for. At the same time, the use of real-life objects as interfaces to information also excites us. TaPuMa is a natural blend of these interests in using tangible media to acquire digital information.

This paper presents TaPuMa - a Tangible Public Map. We also discuss how does TaPuMa work and implementation details of the first prototype we build for an airport scenario. In the later part of the paper, we briefly list some of the pros and cons of TaPuMa along with the challenges relevant to the vision of interacting with information using real life objects.

2. RELATED WORK

Map has been regarded as an important application field in many tangible user interfaces. Projects such as TASM (Tangible Augmented Street Map) [7] and metaDESK [12] have shown new tangible mechanism to use digital maps. Many research projects and commercial products available today use table-top mechanisms to provide tangible interaction with information. Sensetable [10], Microsoft Surface [6], Entertaible [3] from Philips Research are a few among them. These platforms have successfully shown multi-touch or token based tangible interactions for zooming, panning and rotating for maps on table-top settings. Using physical objects to interact with digital information in tangible user interfaces [11] is not a new phenomenon anymore. SnapLink [9] proposed color-based object registration and recognition mechanism for augmented desk interface in compare to the tag-based registration of Sensetable. Project Rasa [5] explored the possibilities of augmenting physical sticky notes on maps and use them to provide paper-based command and control capability in a military command post. On the other hand, Matkovic et al. [4] have made a system which uses tangible interfaces as queries. In their system, users can search images by putting many small color cubes on a semi-transparent glass plate.

Although many table-top tangible interfaces such as metaDESK use physical objects to interact with digital projected maps, none of these interfaces use real-life objects as queries to find locations or information on the map. The physical objects(tokens) used in these systems act as control points for operations such as zooming, panning and rotating the map. Use of sticky notes as tokens in Rasa limits the use of real-life objects in tangible interactions to one specific object only. Object detection capabilities of products such as Sensetable, Entertaible and SnapLink limit them to specific developed tokens or colors. The new platforms such as Microsoft Surface along with the advanced computer-vision based object detection algorithms creates opportunities to leverage the use of real-life objects as keywords to find information in a more intuitive and tangible way.

3. TAPUMA – TANGIBLE PUBLIC MAP

3.1 What is TaPuMa?

TaPuMa is a digital, tangible public map that allows people to use their own belongings or the everyday objects they carry with them

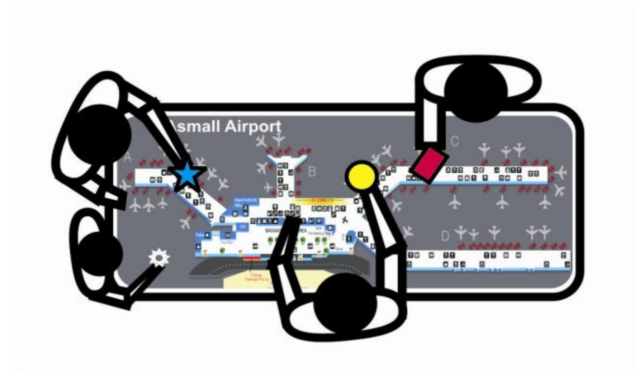

Figure 1. Multiple users interacting with TaPuMa using real-life objects.

to access relevant information. The key features of TaPuMa are as follows.

Physical objects as keywords: TaPuMa allows users to acquire information through tangible media, the things they carry. In a typical case, a TaPuMa user can put on the map a physical object, which serves as identification for desired information or location. TaPuMa recognizes the object and provides the user with relevant filtered data. The use of physical objects for information acquirement is similar to the use of keywords in searching for information in search engines such as Google and Yahoo!, with the media of language replaced by tangible everyday objects.

Locations and non-spatial information: As a digital information acquirement system, TaPuMa can provide more than spatial directions. Transcending the common concept of a map helpful in finding physical locations, TaPuMa is a digital map capable of providing instant information and displaying relevant data of the tangible objects put on it. For instance, when a student puts his school ID card on the top of a TaPuMa on campus, the TaPuMa identifies student, the owner of the ID card, and displays his class schedule. The system also provides him with the path from his present location to the location of the classroom, his class is scheduled in.

Multiple user interaction: As shown in figure 1. TaPuMa exhibits its multi-tasking capability by allowing multiple users to interact with the system and retrieve information on the map simultaneously. For example, if user A puts object-1 on a TaPuMa, intending to find location X, while user B puts object-2, on the TaPuMa, intending to find location or information Y, the TaPuMa provides user A and user B with X and Y at the same time. Multiple users can interact with TaPuMa using their own interfaces - their belongings.

Dynamic and contextual information: Information change. More than retrieving instant information, TaPuMa provides dynamic and contextual information in just-in-time manner. Updates or addition of incoming new information are displayed to a user even if he holds the same object on the map without “refreshing” the map. In addition, the emphasis respect to the information changes and the amount of information provided are flexible according to a user’s practical need. For example, TaPuMa can provide a user with dynamic information such as time delay in flight departure when he uses his boarding pass with TaPuMa at an airport. Even though the boarding pass here is a passive printed piece of paper, TaPuMa augments it with dynamic and more relevant information.

While we foresee the TaPuMa being used in a variety of settings such as cities, parks, shopping malls, and movie theaters, here we present a use-scenario of TaPuMa in an airport setting in order to explain key features of TaPuMa. In the scenario, a Chinese family, Mr. Lee, Mrs. Lee, and their children use TaPuMa in an airport to find check-in counter, look for nearby facilities, locate each other, and board their plane on time.

Mr. Lee, his wife, and their two children have just entered the airport and need to check in for their flight. Mr. Lee sees a TaPuMa, walks up to it with his family, and places his passport on the map. The TaPuMa recognizes Mr. Lee's passport and figures out that Mr. Lee and his family have a flight today but have not yet checked in. It displays on the map the path between Mr. Lee's current location and the airline counter where he may check-in. The TaPuMa also recognizes that Mr. Lee has a Chinese passport and displays information in Chinese. After reading the information Mr. Lee picks up his passport and takes his family to check in.

When everyone in the family has checked in, Mr.Lee wants to figure out how to go to the boarding gate. He places his boarding pass on a nearby TaPuMa, which shows the path from his location to his gate. It also displays the time at which his flight will board. Mr. Lee and his family make their way to the gate.

After passing through the security checkpoint, they realized that the gate is far away and they still have more than an hour before the plane will board. Mrs. Lee decides that she wants to go shopping with the children while waiting for boarding. She approaches a TaPuMa and puts her ATM card on the map. A table of options shows up around Mrs. Lee's ATM card: Shopping, ATM machines, and Currency Exchange. Mrs. Lee presses the Shopping icon and the locations of stores appear on the map. Mrs.Lee and her children go to the stores according to the path indicated on the map.

Meanwhile, Mr. Lee would like to find a designated area to smoke. He places his package of cigarettes on the TaPuMa to find out where to smoke. A table appears around the package and shows two options: Smoking Area and Stores that sell the types of cigarette that Mr. Lee has. He selects Smoking Areas and then is directed to the closest designated smoking area by TaPuMa.

When Mr. Lee finishes his cigarette he goes to the stores where his family went. Unfortunately they are no longer there. Nervous about getting to the boarding gate on time, Mr. Lee goes to the TaPuMa to find their locations. He places his boarding pass on the TaPuMa. TaPuMa, recognizing Mr. Lee's boarding pass, figures out that he checked in with a group of people and displays the location of the other group members, Mrs.Lee and the children. At the same time, TaPuMa notifies Mr.Lee a new incoming message: the boarding time of his flight has been delayed for one hour due to the weather condition. Upon seeing the directions and the new message, Mr. Lee leaves to meet his family.

At last, Mr. Lee finds his family and informs them of the new boarding schedule. They continue shopping for some time and then head off to the gate.

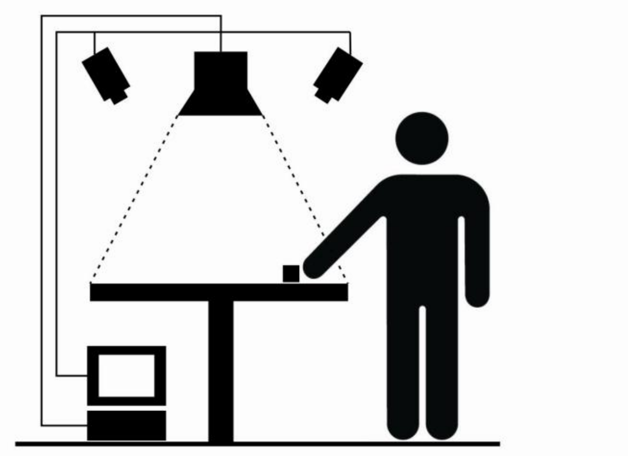

Figure 2. TaPuMa system consisted of a table, a projector, cameras and a computer.

3.2 How does TaPuMa work?

The TaPuMa system (figure 2.) uses a table-top environment where map and dynamic content is projected on the table. A camera mounted above the table identifies and tracks the locations of the objects on the surface. The projector and the camera are connected to a computer. A software program identifies and registers the location of objects on the table. On the basis of identifications of the objects, the software program provides relevant information visualization to be shown on the table. The projector augments the table and objects on the table with projected digital information from overhead along with the map. The system also consist supplementary components such as RFID readers to support the user identification and provide customized information relevant to the user. For example, if a user puts his student ID card on the TaPuMa table surface, the camera mounted above will identifies the object and tracks the position of the card on the table, whereas the RFID reader beneath the table helps in identifying who the student is. Now as the system has information of the student, it processes and provides the relevant information the user may be interested in. This information is projected at the appropriate location on the map with the use of the overhead projector. In the given example, the system shows the schedule of the next class the student needs to attend along with the location of the classroom on the map.

3.3 Implementation

We developed a working prototype of TaPuMa as shown in figure 3. The first prototype of TaPuMa is consisted of a Sensetable, a projector and a laptop computer. Sensetable is a commercial product of NTT Comware corporation which detects IDs and positions of circuit-embedded small plastic packs(tokens) on a table. In the TaPuMa prototype, the Sensetable connects to the computer and Sensetable program which is running on the computer generates and updates an xml file in which positions of each packs on the Sensetable are described. The xml file is loaded by another program that is made using Adobe Flash. The flash program scans and uses the location of the tokens to generate relevant visualization. The projector which is connected to the computer projects the graphics on the Sensetable. We used six

Figure 3. Working prototype of TaPuMa.

everyday objects for the prototype: a passport, a one-dollar bill, a cigarette box, a medicine case, a cup and a boarding pass. We embedded the tokens into each object so that Sensetable can detect the position of each object. The flash program generates graphics for the corresponding objects on the airport map, for example, in figure 3 TaPuMa shows the position and path to the gate when the boarding pass is placed on the surface of TaPuMa. Since Sensetable can detect multiple objects on the map, this prototype can be used by multiple people at the same time.

Each day many tourists besides the students are there at MIT Campus. Currently we are in process of developing a fully working TaPuMa system for MIT campus. We think that such a pilot implementation will give us more insight and understanding about challenges and pros and cons of the novel interaction mechanism. In the new prototype we use OpenCV, an open source computer vision library originally developed by Intel, to detect objects on the surface of the table. The camera, which is connected to a computer, provides real time video to the OpenCV based software, developed with C++. The software uses computer vision techniques for the detection and tracking of the objects. The software has access to images of a predefined set of objects such as ATM cards, student ID cards, currency notes, and passports. Besides this, the system will also be capable to detect everyday objects like coffee cups, keys, mobile phones. We are also exploring the possibilities of using user-defined objects, so that TaPuMa can learn from users about new objects and their relations to the user intentions.

3.4 Advantages and Challenges

The key advantage of TaPuMa lies in the use of real-life objects as interfaces to information. Using objects as keywords for information acquirement also eliminates the language barrier of conventional graphical interfaces. Unlike many current interfaces in public space, TaPuMa enables multiple user interactions. Different people can use the map at the same time and use their own objects on top of the map as queries or hints to information they are looking for. As we all know how to use our own objects, TaPuMa provides a mechanism which requires a very little learning. The other interesting advantage TaPuMa provides is the ability to show dynamic and contextual information. Comparing with static or generic information displays, TaPuMa's contextual, user-specific and dynamic information providing capability can dramatically improve the efficiency in information acquirement. By letting people use the objects they carry around as hints, TaPuMa offers an intimate and intuitive information experience.

At present, object detection technologies are still not mature and foolproof. Although, computer-vision based object detection is getting better and better there are still challenges featuring lighting conditions, movement, orientation of objects, and liability of such systems. At the other end tangible world also has limitations. It is a very likely case that user is not carrying objects which is a hint to the information he is interested in. It is also impossible to map all the possible information we seek for to our objects. Using objects as keywords can also be ambiguous, as there can be more than one mapping to actions or information are possible. We also observed that different people in different places, age-group, and culture have different meanings to objects. Despite all these challenges, we think that the new interaction mechanism proposed in TaPuMa can definitely find its niche. It is also possible that rather than replacing the conventional interaction mechanisms, the new mechanism can provide and add an alternate method to information acquirement.

4. FUTURE WORK AND DISCUSSIONS

The first prototype of TaPuMa was developed for airports. With TaPuMa, maps in the places like airports, shopping malls, movie theaters, where people usually carry similar objects with them, are less challenging than generic public maps in a city or town. We plan to understand and explore such more challenging situations in the next steps of the project. We are in process of developing a

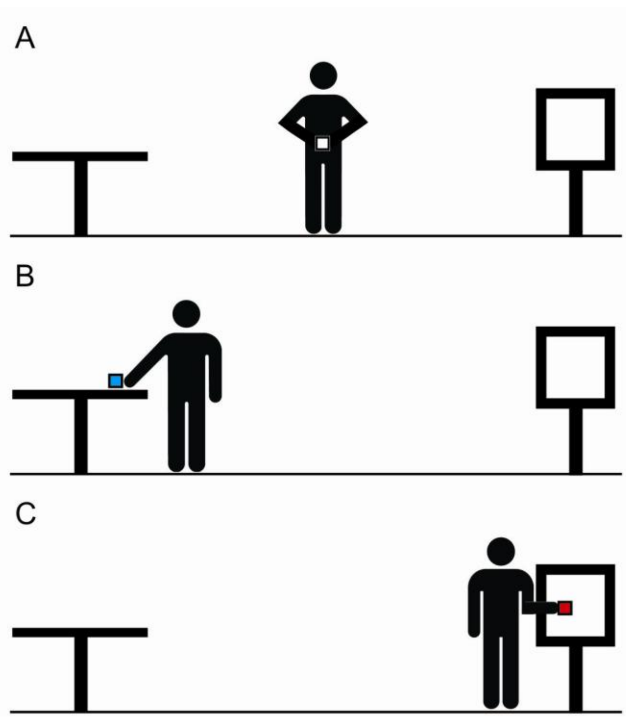

Figure 4. Concept of Object Amelioration. (A) user with his object (B) user's object augmented when used with a system (C) user's object augmented differently when used with another system.

fully working TaPuMa system for MIT Campus. We plan to conduct qualitative and quantitative studies to capture user feedbacks. We also plan to report on these results.

TaPuMa is based on the concept of Object Amelioration - everyday objects' functionalities can be expanded by using their identities and affordances in different contexts. The concept of Object Amelioration can be illustrated as shown in figure 4. Figure 4 (A) shows a user with his object. The object is enhanced or augmented by an Object Amelioration system (e.g. TaPuMa) (figure 4 (B).) The same object is augmented in different way when used in the context of another Object Amelioration system (figure 4 (C).) User's object is same, whereas the object is ameliorated contextually when used in different context. We will be interested in studying how the use of real-life objects in an environment that is consisted of multiple Object Amelioration systems makes the objects around us mean more that what they are.

5. CONCLUSION

In this paper, we present TaPuMa – a tangible public map which uses real life objects as filters to provide relevant information and find locations. TaPuMa envisions that conventional maps can be augmented by using the unique identities and affordances of the everyday objects, the objects that we carry with us. The paper proposes a novel interaction mechanism where physical objects are used as interfaces to digital information. We think maps will exist as long as human existence continues; everyday objects as well. TaPuMa is an attempt to connect the both in an intuitive way and to seamlessly bridge the gap between our physical and informational worlds.

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