Ambient Intelligence with Personal Media

Yang Cai
Human-Computer Interaction Institute
Carnegie Mellon University
5000 Forbes Ave., Pittsburgh, USA
ycai@cmu.edu

ABSTRACT
Ambient intelligence with personal media is an emergent area that has impact on scientific discovery in life science, healthcare and social studies. The paper introduces case studies in building those personal media for scientific discovery. Feature tracking and feature registration are two major technical challenges in the personal media based data mining. The author explores the relative object registration method that can recover the spatial relationship in the tracking map. In addition, privacy in mining through personal media is discussed in the paper as a risk for ambient intelligence.

Author Keywords
ambient intelligence, discovery, human modeling

ACM Classification Keywords
information interfaces and presentation

INTRODUCTION
Human modeling has been studied for decades, from healthcare, security to filmmaking. It has become a renaissance area because of: 1) the need for affordable personal healthcare, such as capsule medical cameras, 2) emerging global population aging problems, 3) the threats of global terrorism, and 4) usability studies for field equipment such as metal detectors and automobiles.

Personal media, such as wearable devices, portable devices and their interactions can generate enormous data set. The advantage of the personal media is that it can provide continuous coverage of the personal information. Studies have been conducted to collect personal health data from a wearable armband [Bodymedia, 2004]. However, mining through the personal media can be a challenge. Although today's technologies enable affordable and efficient data collection for human modeling, the post-processing and analysis are still tedious and time-consuming, which involve unstructured information in the form of geographical location, image, text, audio and video content is fast becoming a daily activity for many people. Increasingly, the content is overwhelming limited human perceptual capabilities. For example, it took an analyst about 10 hours to map a 20 minutes video tape from a human subject study. We ought to develop ambient intelligence systems for automated or semi-automated analysis.

MODELING ISSUES

Mobile devices such as handheld computers, wearable cameras or cellular phones are important personal media source for human modeling, for example, personal bioinformatics, human field performance studies and wireless interaction studies. To extract the useful patterns from personal media, we need to fuse physical sciences, such as imaging, pattern recognition methods with soft computing methods such as data mining and visualization. The general process includes algorithms of feature tracking, and feature registration.

- Feature tracking: we develop algorithms for tracking features such as color, texture, shape and location both in space and time dimensions.
- Feature registration: For personal media, object registration is a challenge because of noises and distortions. A novel registration method, Relative Object Registration has been developed. Instead of registering the absolute location of an object on a geographical map, an object can be measured and registered by a reference object in the image.

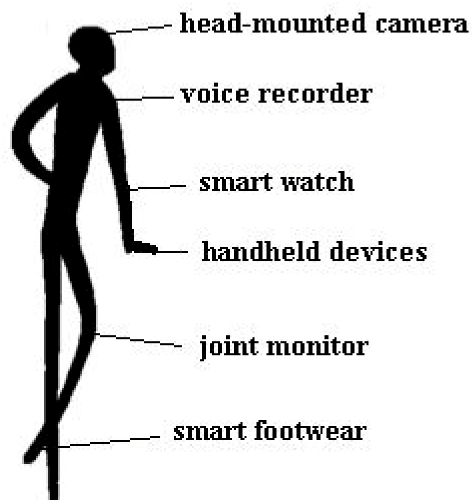

Figure 1. Personal Media

In this paper, the author presents three concept designs for observing the human from personal bioinformatics to mobile interaction and social interaction, e.g. *personal bioinformatics*, e.g. the ambient healthcare toolkit, tongue inspection system (TONGUE), based on Traditional Chinese Medicine; Second, the *wearable imaging* systems, e.g. the head-mounted video camera-based landmine detection performance analysis system (PROB); Third, the *wireless mapping* system (CMUSky) that registers wireless users in the field for studying the dynamics of social computing.

PERSONAL BIOINFORMATICS

Personal bioinformatics is based on human features, such as blood pressure, temperature, skin color and facial expression. Regular lab tests cost are significantly to a patient. It is has been a big burden to economy. With the growing aging population, affordable personal bioinformatics is desirable.

For over two thousand years, visual inspection of the tongue has been a unique and important diagnostic method of Traditional Chinese Medicine (TCM). Observing the abnormal changes in the tongue proper and the tongue coating can aid in diagnosing diseases. Clinic data have shown significant connections between various viscera cancers and abnormalities in the tongue and the tongue coating [Cai 2002].

Visual inspection of the tongue offers many advantages: it is a non-invasive diagnosis method, is simple and inexpensive. We use a digital imaging system to make a picture of a patient's tongue, then use software to extract the features from the image, and finally make a diagnosis based on quantitative models. Our goal is not to replace the conventional diagnostic methods but to give an early alert signal that can lead to further diagnosis by other methods, such as MRI, CT, X-ray, colonoscopy, etc.

The imaging system consists of image acquisition, image processing, feature representation, and diagnostic models. We built a handheld scanner for tongue imaging. Figure 2 shows a sample image.

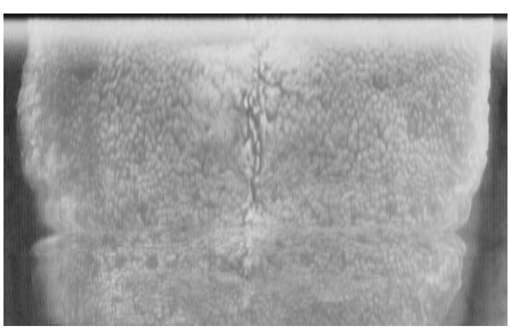

Figure 2. Portable Tongue Scanner

We crop the tongue shape from the raw image with active contour tracking algorithm [Cai, 2002] and then convert the tongue image from the color space of RGB to L*a*b so that we can represent the color feature with only two parameters, *a and *b. To represent the texture feature, we use Entropy and Energy Functions [Cai, 2002]. Finally, we use apply data clustering algorithm and 3D visualization to classify the data. Currently, we are studying the correlations between colon polyps and feature changes on the tongue.

MOBILE IMAGING

The current head-mounted camera-based lip and eye movement tracking systems only observe a single component on human face. Here the author focuses on a broader problem: "how to visually evaluate human field performance with a head-mounted video camera?" The goal of this study is to develop a computerized object tracking and mapping system that can automatically register the moving target to a trajectory map. This study uses military landmine detection video as a case study and uses computer vision algorithms to map the original video data to a dynamic tracking graph. It is expected that the method can be applied to other fields, such as behavior measurement for elderly in nursing homes, user performance modeling for airplane inspection, etc. [Cai, 2003]

Figure 3. Object Tracking from the Video

Because a head-mounted camera has at least four degrees of freedom (DOF), the images in the video are geometrically distorted. For target tracking purposes, we only need the relative coordinators and distances referenced to the landmark and the plane of the landmarks. In light of the shortcomings of the transformation, this study focuses on the "*relative registration.*"

Relative registration is a non-metric measurement method in which a target is not only just an object but also a reference itself. It is an approximate way for a quick measurement of the object's size and the distance between things. For example, artists often use "number of heads" to measure human figure's height and use "number of eyes" to measure the width of face. This is based on observations of our daily life. Our perception systems have "internal yardsticks" for qualitative measurement. Our eyes do not make absolute measures of characteristic of the subject, but instead detect these characteristics only in a relative way. We do not see the true color of a thing, but rather an apparent color, which is our sensation of how a color is different from the colors surrounding it.

A trajectory map is a 2D or a 3D space that is registered with a dynamic trace of a target. It is a visual model of human field performance dynamics, for example, search patterns, pace, and sweeping patterns, etc. Fig.4 shows a comparison of a trace of a sweeping metal detector from an expert and a novice. From the map we discovered that the trace of the expert is uniform and thorough. However, the trace of the novice is uneven that contains missing spots.

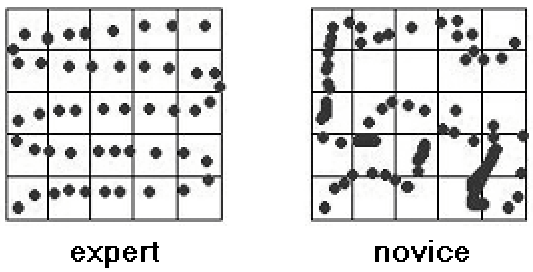

Figure 4. Object Trajectory Maps

WIRELESS MAPPING

Mobile devices, such as cellular phones and handheld wireless connections emit radio signals to the receivers. By triangulation the signal strength from multiple access points, the user location and identification can be recovered and mapped onto an overview screen and a database.

CMUSky started as an art project at the Innovation Process class at Carnegie Mellon University (CMU). It was originally designed for real-time mapping wireless users on campus and rendering the people's interaction distributions both in space and time dimensions. It has soon become an Ambient Intelligence tool for studying the wireless interaction patterns, for example, the rhythm of students' working patterns throughout the week and the laptop distributions in different buildings on campus, which provides valuable data for studying social computing and human interaction. For example, there were three 'hot spots' on campus where more people used laptops: the buildings for computer science (Wean Hall, Newell-Simon Hall) and the Tepper School of (Porner Hall). Counter-intuitively, business students have more laptops than computer science students, because they were required to have one for each student.

Similar systems can be applied to monitoring the elderly's daily routine, childcare, emergency response and to enhance the security surveillance.

CONCLUSION

Ambient intelligence with personal media is an emergent technology that has profound impact on our life as well as

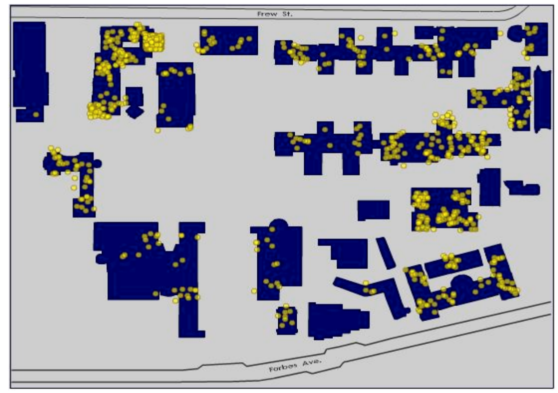

Figure 5. CMUSky Overview Screen

scientific discovery in life science, healthcare and social studies. The paper introduced cases in building the personal media for scientific discovery. Future tracking and feature registration are two major technical challenges in the personal media based data mining. In this paper, the author explored the relative object registration method and multidimensional surface feature (color and texture) fusion method. Results show that those novel algorithms enable human modeling from the ambient personal data.

For many ambient intelligence systems, the extracted features are invisible, such as infrared imaging data or wireless data. With visualization tools, we can transform the invisible to visible. Furthermore, with the object tracking and registration, users can study the human characteristics, behavior or interaction with the digested information, such as an overview screen or a 2D/3D map of clustered data.

Ambient intelligence enables us to mine valuable knowledge through personal media. However, there is a risk of privacy invasion in ambient intelligence, for example the location of a laptop user. To protect the privacy of users, we encrypted user's identity with dots instead of user identifications.

In next ten years, we will see many ambient intelligence products for health informatics, elderly care, education or entertainment. The affordability and privacy are two obstacles through the development. Innovative concept designs are a major power behind the new wave of industrial revolution.

REFERENCE

[1] Bodymedia web link: www.bodymedia.com

[2] Cai.Y, A Novel Imaging System for Tongue Inspection, IEEE IMTC, Alaska, 2002

[3] Cai.Y 2003, Trajectory Mapping from a HMD, ICCS, Melbourne, 2003

[4] CMUSky web link: www.cmusky.org