Fast detection and visualization with Parallel Coordinates of Automated Living Context-Awareness Environments

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Abstract—This paper presents *The parallel Coordinates Automated Living Context-Awareness Visualization (PCALCAV).* The system applies to the maintenance of health care for disabled/elderly people by monitoring their health status and their caretakers activities daily routines in their own environment. This includes, the number and time of door openings, the length of sleep, absences from the house and much more are clearly identified directly or from combining several sensor outputs. We monitored the daily behavior of four caretakers of the patients having is serious illness needing to stay in bed at all times. Several sensors were installed and integrated with an embedded system and which uses wired or wireless communication technology such as ZegBee and RFID. Data gathered are then stored in a storage device or transferred via Local Area Network (LAN) to a remote storage location where separate analysis and planning can be performed. Furthermore, the degree of dependence and usage of the subject on different household devices can be determined. This information is then be compiled and sent to the different units responsible such as household managers or family members in order to make informed decisions regarding the needs of the people under care. PCALCAV displays in house activities in parallel coordinates [2]. From the observation of each RFID for users tagged as #123, #121, #120, #117, we develop hypotheses and the monitor mechanism based on an efficient hashing algorithm. Using the graphical signatures, PCALCAV can quickly find patterns which seem abnormal enabling members of the family via text message or voice contact to intuitively recognize and respond to the matter in hand. Compared with existing visualization works, PCALCAV can handle hyper dimensions, i.e. can visualize many more than 3 parameters if necessary. This significantly reduces false positives obtained based on incomplete information. As a consequence, abnormal behavior is more precisely detectable by machine and more easily recognizable by human. Another strength of PCALCAV is handling of two device ZigBee and RFID sensors time flows. Pre-flow visualization greatly reduces the processing time and further provides compatibility with two sensors which export flow information. We demonstrate the effectiveness of PCALCAV using real-life data activated monitoring traces so of the so-called "Smart housekeeping system with a network of living-context awareness assistive service".

Key words—Parallel Coordinates, Automated Living Context-Awareness Visualization, Health monitoring at home, Remote Monitoring.

I. Introduction

Recognizing human activities using sensors is currently a major challenge in research[6]. Typically, the information extracted directly from sensors is either not clear enough or is too noisy to accurately infer activities occurring in the scene. Human activities are complex and evolve dynamically over time. To overcome these drawbacks a promising approach is the visualization of complex situations in a simple and intuitive way as in [1].

Visualization is not about seeing zillions but rather perceiving relations among them. With Parallel Coordinates (abbr. ||-coords) the search for multivariate relations is transformed into a 2-dimensional pattern recognition problem [2]. For a multivariate dataset, in general, our goal is to concentrate the relational information into clear patterns eliminating the polygonal lines altogether. The methodology's foundations are quickly reviewed and then our vision for the future is illustrated with a challenging example ([3], [4]), interesting in its own right, and having important applications from regression to machine learning [5] .

The novelty of the paper is two-fold: a) We present the first work in applying the ||-coords methodology for activity recognition, and b) we analysis and compare the different days (or users) to better understand the dataset.

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The organization of the paper is as follows. In the next section related work is reviewed. Section 2 presents the basic concept of ||-coords detailing how visualization methodology is employed to detect the relationship between dataset's parameters.. Section 3 goes into the details of efficient simulations. We then describe our experiments and results in applying the model to home care based human activity recognition in an indoor environment. The conclusions is given last section..

II. SMART HOUSEKEEPING SYSTEM WITH A NETWORK OF LIVING CONTEXT – AWARENESS ASSISTIVE SERVICE

A. The Smart Housekeeping System

The monitoring system was designed 'to work long term, without any human operation throughout its operational period. The system included a personal computer, different sensors integrated with an embedded system and uses wired or wireless communication technology such as ZigBee and RFID, amplifiers, a network and an ISDN modem. In the current system, Microsofi Windows XP was used as the operating system. The system consisted of two components: data acquisition and data transfer.

1) Data Acquisition

In order to devise a visual mechanism for the smart housekeeping system, their characteristics need to be considered in terms of visualization. RFID and ZigBee are chosen. The selected sensors were both easy to install and use, and they did not disturb the daily behavior of the subjects. The following sensors were selected.

1. Pyroelectronic Infrared Photoresister sensors were used to detect doors opening and closing.
2. Hall Currency sensors were used for detecting electricity socket.
3. Reed Switch is used for detecting door opening/closing.
4. Infrared sensor were used to mark and detect the locations in the house.
5. Interrupt sensors were used to detect the passage of a human.
6. RFID's tags are carried by 4 person (#123 father, #121 sister, #120 mother, #117 uncle, the patience stays in his room all the time so that he does not carry the RFID tag)

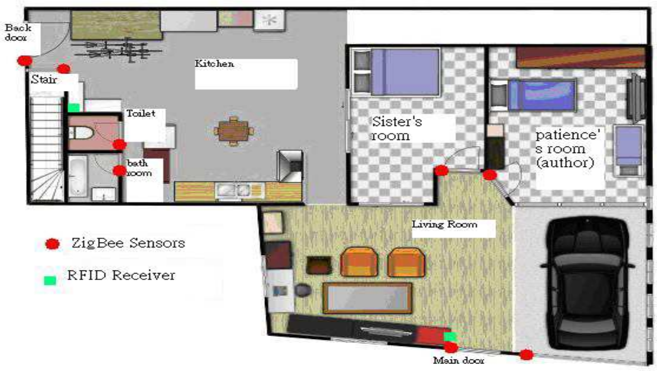

Figure 1: The schema of house and two devices installed

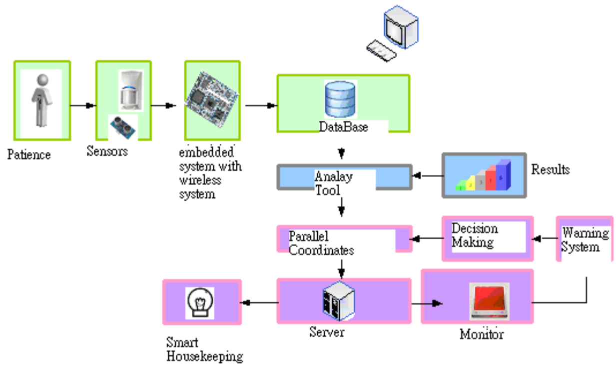

Figure 2: The schema of the Smart Housekeeping System with a Network of Living Context-Awareness Assistive service system design of PCALCAV

The output data gathered are then stored in a storage device.

2) Data Transfer

To achieve remote monitoring, the data were automatically transferred daily to another site ***via*** the Internet via Local Area Network (LAN) to a remote storage location to perform separate analysis and planning.

3) Parallel Coordinates

One important aspect of information visualization is scalability. Parallel coordinates provide great scalability to multiple dimensions. They are not complex, yet allow hyper dimensional patterns to be analyzed, They lead to a quick intuitive understanding of the information. This technique has no theoretical limit in the number of parameters that can be visualized. Therefore, we can scale up the application by incrementally introducing new visualization parameters as necessary. Moreover, it does not introduce bias for any specific dimension, while showing prominent trends, correlations and divergences from the raw data. These advantages enable us to gain critical insight into the dataset for the different RFID's tag users being tested and establishing reliable hypotheses. Even if an abnormal behavior occurs a specific image pattern can be obtained and the behavior can be detected then (and later) in a timely manner.

III. SIMULATION

A. Dataset

The Automated Living Context-Awareness dataset was collected. Data was collected automatically during the experiment, and the data transfer process was deemed successful. During the long-term monitoring (in total, over about three months), the system sometimes experienced troubles. However, we were able to fix these, and so demonstrate the robustness of the system. The computer sometimes stalled, and this was considered the biggest problem of the system. The shut down of the computer may have been due to instability of the Microsoft Windows XP operating system with long-term operation. The next version will use LINUX or Microsoft Windows XP as the operating system.

Fig. 3 shows The schema of the Smart Housekeeping System with a Network of Living Context-Awareness Assistive service**,** how the dataset can be obtained during a day from the house of subjects**.**

RFID's tags are carried by 4 person (#123 father, #121 sister, #120 mother, #117 uncle, the patience stays in his room all the time so that he does not carry the RFID tag) who take care of Patience (author) by 24 hours in shift. Sensors were installed in main entrance, back door, sister room, author room, bathroom at the upstairs , toilet at the upstairs and stair. The quality of RFIF performance are measured by distance, LQI (Link Quality Index) and Power. The system is monitoring the whole RFID's tags users daily behavior. Using the system, the 4 subjects were monitored from September 22nd, 2012 to January 2013. The subjects signed consent forms. Fig. 1 shows the floor plan of the house with the installed sensor locations. Each data set obtained was checked daily by a research student. When a problem was found the research student would make a telephone call to the subject to discuss the situation.

B. Data Preprocessing

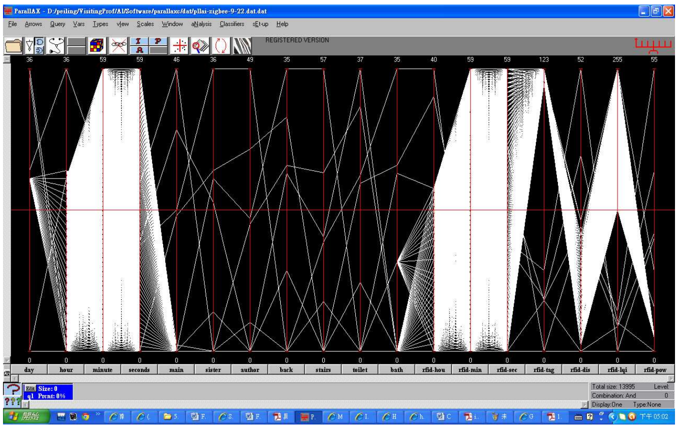

Figure 3: 9/22/2013 dataset-Original with 13995 data entries, note outliers

Fig 3 shows the parallel coordinates (abbr.||-coords) [2] method to perform the dataset. A dataset *P* with *N* variables is transformed into a set of points in *N* dimensional space. Information of daily behaviors, such as the number of door openings, the length of sleep, absences from the house, use of a bathroom or toilet, walking on the stairs were clearly identified using either a single sensor output, or by combining several sensor outputs.

C. Patitioning the Problem

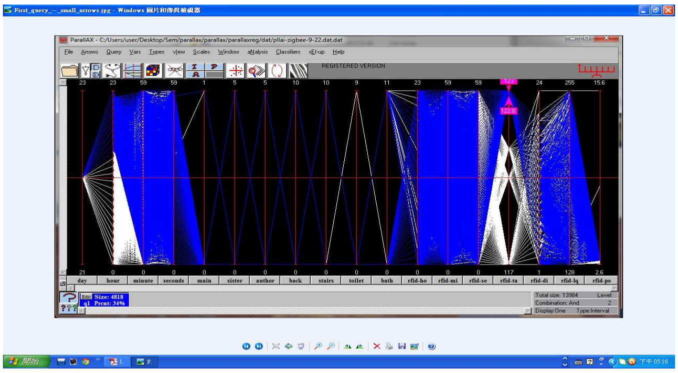

Figure 4: After cropping outliers there are 13984 data entries

We want to look into the dataset according the RFID users now. After cropping the outliers, there are 13984 data entries as Fig 4. It is easy to estimate that some regular daily behaviors can be observed from the sensor outputs as Fig 5. We found RFID users #123, #121, #120 and #117 turned up the house at different CONSECUTIVE times for 24 hours.

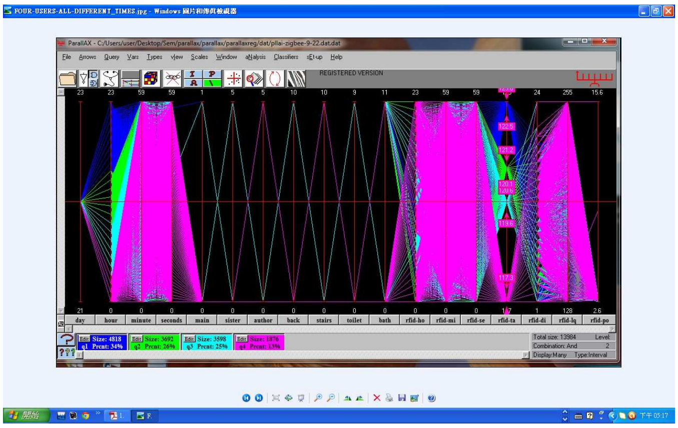

Figure 5 Each RFID users from #123 #121 #120 and #117 shows in house for the duty one after the other round 24 hours.

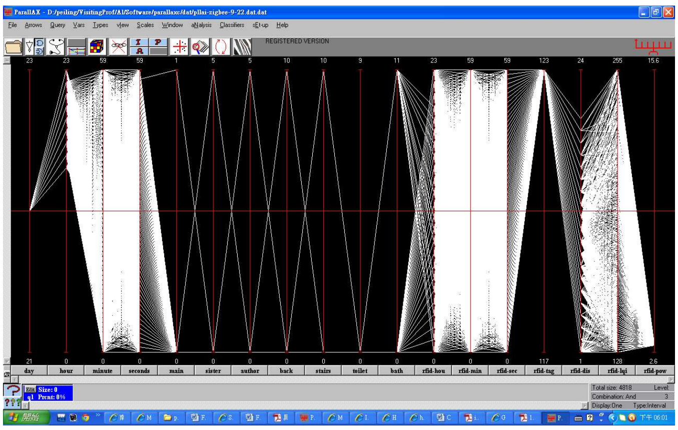

Figure 6: #123 activity in the house environment.

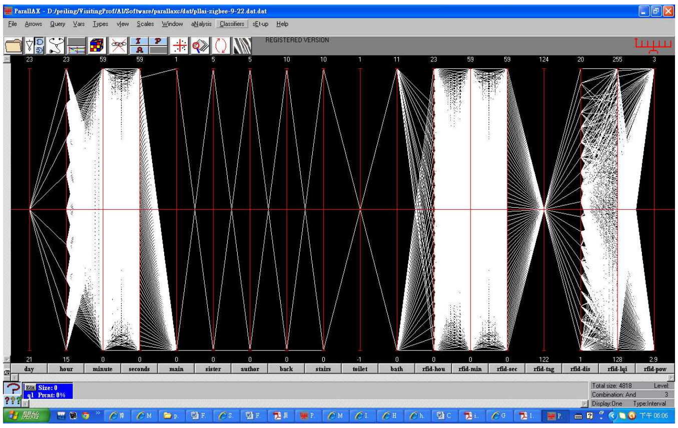

Figure 6: By isolating and rescaling the activity of user #123 one can easily to see that he stayed in house between 15 to 23 hours, entered from main door, went to the sister and author's room, went to upstairs to the bathroom and used back door as well. He was a very active person.

Similarly we also can see from the data that #121, #120 and #117 stayed in house 6 hours, 6 hours and 4 hours respectively.

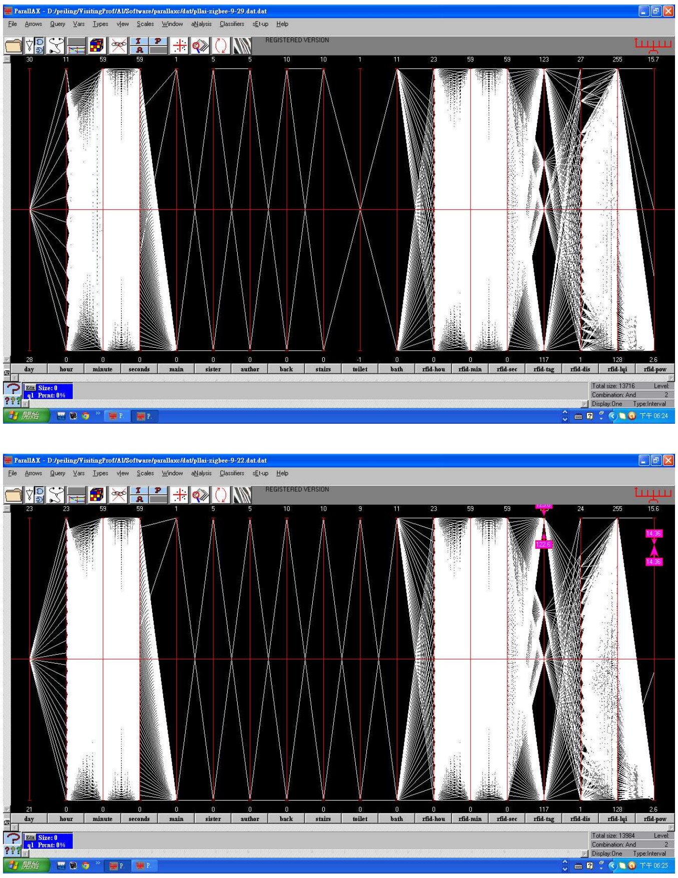

Figure 7 comparing two day 9/22 and 9/29, the last colum of RFID power

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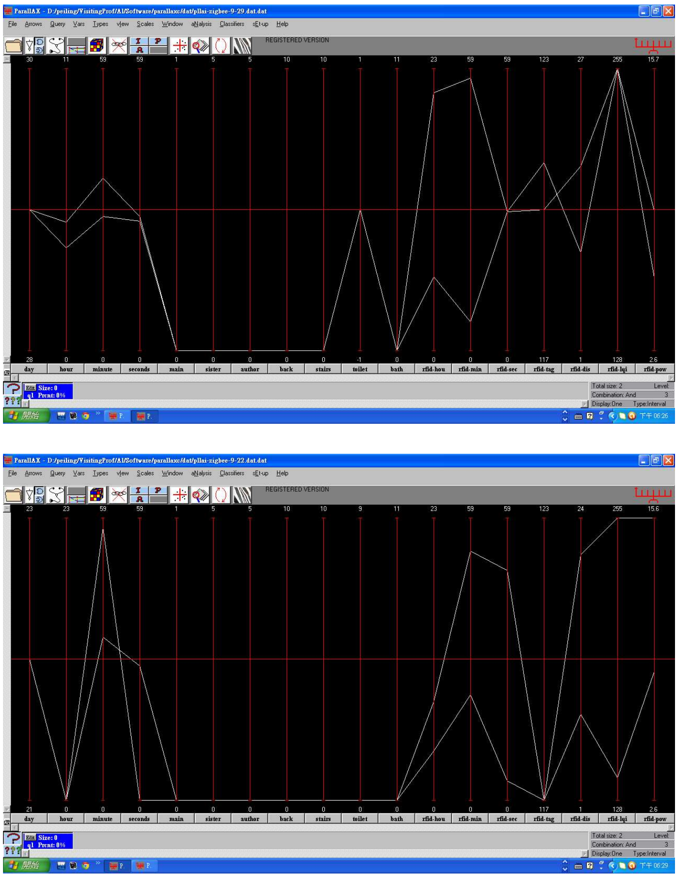

Figure 8: The bottom value in 9/22 of RFID power happened middle and high are related with #117 and LQI shows that one is good while the other one is low. Moreover the top picture 9/29 shows the power separately by #121 and #120 and the LQI is very high

In Fig. 7, 8, we compared the different days. We found the interesting relationship between RFID powder, LQI and users.

The daily behavior can be monitored with only simple sensors and a commercial industrial network. No special devices were introduced. Therefore, we think that such behavioral monitoring can not only contribute to the maintenance of health but other activities such as posting moving guards in building facilities for example.

IV. Conclusion

Research on the "Smart housekeeping system with a network of living-context awareness assistive service" by using several simple sensors was selected with a data acquisition system designed for monitoring daily behavior in the home. In addition, to achieve remote monitoring, data were transferred to another host via the Internet using wired or wireless LAN. The monitoring was evaluated practically with an experiment involving one domestic house that was inhabited by a seriously ill person with four caretakers.. Data originating from their daily behaviors were obtained automatically from a remote location. Some daily behavior patterns could be recognized from the data showing that such monitoring can greatly aid in the maintenance of a home care system.

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