Inferring Students' Activity Using RFID and Ontology

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Abstract. This work presents a method to monitor students in a campus area for headcount in an area and activity of student. For high accuracy and real-time data, RFID readers are exploited and located at the fronts of every door of a room to identify students in the area. Ontology was created to represent room type and activity that can happen in a room. With the ontology, we can infer activity of students using an inference engine embedded in OAM framework based on RFID data and basic data from university. To make data easier for campus personnel in management, visualization systems are implemented. These are a visualization to display crowd in a campus area and a visualization tool for student activity.

Keywords: Activity inference · Smart Campus · Crowd detection · Visualization · Ontology application

1 Introduction

A campus is where university or college buildings are situated. In campus, people are most crowded in office days for many reasons such as doing educational activities, group meeting, skill training, entertaining activities, etc. To make a smooth running, management within campus is greatly required. The management in campus is such as facility provision, security, and transportation service. In fact, making a good management requires a lot of information [1] in many regards including headcount in area, student schedule and a list of events. Commonly, the information comes from human monitoring, but it may not reflect actual circumstances from in-sufficient staffs. Hence, an automatic method to gain or accurately estimate the information is highly preferred.

In the past, some researches proposed on gaining the headcount and student movement data. [2] and [3] suggested to use basic data of students' schedule from their course enrollment to create a movement path of a student. They applied ontology as their schema for the base of their services. These works have an advantage on using data that are free and easy to access to estimate student whereabouts, but their method is in doubt in accuracy since the data in use are static and do not represent real-time situation. In the other hands, some works mentioned in using sensors to track students. [4] published an idea to use active RFID [5] to read student location

adfa, p. 1, 2011.

from items carrying by students. This work acquires the real-time data of student whereabouts and their identification, and these data can make an accurate headcount of students in areas for security and authentication purpose.

However, none of the above mentioned researches mentioned on student activities in the presence although they obtained students' location. Students' activities are one of the most required data for managing facilities and safety. In this work, our goal is to acquire students' activities using identification from RFID with ontology based inference. To combine data of who, where and when, we can semantically infer activities of students using knowledge representing an ontology, inference engine and real-time data.

2 Background

There are some existing researches focusing on activity recognition and headcount in campus detection. We review their works and summarize them in this section. Moreover, we briefly explain an Ontology Application Management (OAM) framework that we use as a core in inference an activity in this work.

2.1 Related Works

Recently, a work on student movement and headcount detection [3] was published. This paper described on using ontology as a schema to collect student data in campus and recommending a transportation plan according to student headcount and movement. This work applied reasoning engine to assign a transportation path and amount of shuttle buses using ontology based inference. Their experiment result showed a potential of ontology to manage campus data and proved ontological based inference of its usefulness in complex decision-making. However, this work only used general static data from university as their input. The data thus do not reflect actual headcount and movement. Hence, we can conclude that the work has a weak point in using an estimation of student amount, and the result would not be accurate in the actual situation.

Another publication is about activity recognition using ontology with context in a home [6]. This work applied object based sensors to read human action in a home. With the gained sensor data, inference engine was utilized to reason and result in guessing an activity of a person who interacts with the object. This work showed a good success on using logic and reasoning with ontology in recognizing activity in home. Unfortunately, home activities are limited to objects existing in home in which are different from other places. They cannot directly apply to another location. Moreover, the work focused on a single user in a home while an amount of persons in large place such as university campus could apparently be over a hundred participations.

2.2 Ontology Application Management (OAM) framework

Ontology Application Management (OAM) framework is an application development platform created to support in a development of an ontology-based application [7]. This framework is an integrated platform that supports both RDF data publishing from databases based on domain ontology and processing of the published data in ontology-based applications, i.e. semantic search and recommender system applications. It provides a user interface for ontology-data mapping, a semantic search engine and interface, and recommendation system engine.

The framework was implemented on top of existing Semantic Web data and application platforms that are D2RQ [8], Jena's RDF data storage and Jena's reasoning engine [9]. However, the provided interface can help users to skip a process to directly use of complex syntax of Jena's reasoning engine.

In this work, we apply OAM for ontology-data mapping and rule generation. With the support from OAM, we can create a rule to determine an activity from instances in spreadsheet [10] without knowing syntax of JENA.

3 Inferring Students' Activity Using RFID and Ontology

This work uses two sources of data. The first one is static data about students and course. The second one is data obtained from RFID to get identification, location and time of students. An ontology schema is designed to cover aspects of the data stored in database, and mapping between ontology and database are done. With the ontology, an inference engine can infer an activity according to a semantic of a given person, location and time. An overview of the proposed method is illustrated in Fig. 1.

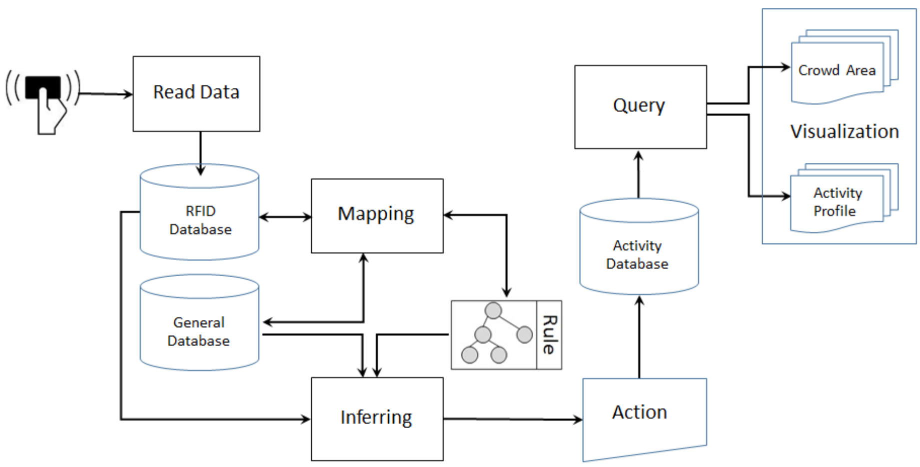

Fig. 1. An overview of Inferring Students' Activity Using RFID and Ontology

3.1 Data Collection

3.1.1 Basic Data of Students

This part describes about general data from university database. These data include information of students, courses and buildings as shown in Table 1 and 2 respectively. These data are used as reference for real-time data.

Table 1. Basic data of students including ID, name and registered subjects

Student ID	Name	Semester	Year	Subject	GPA
258xxx0211	SUxxx S.	1	2016	ICT-261, LAW-101, ICT-392	3.01
258xxx0393	PIMxxx T.	1	2016	ICT-261, LAW-101, ICT-392	2.5
258xxx0454	KAxxxDA J.	1	2016	ICT-252, ICT-392, DIM-101	3.00
258xxx0987	WIxxxPHOL J.	1	2016	DIM-101, ICT-261, ICT-392	2.75

Table 2. Basic data of study courses and their assigned room and building

Subject	Room.	Building
DIM-101	03211	3
ICT-252	05209	5
ICT-261	02203	2
ICT-392	05210	5
LAW-101	01203	1

3.1.2 RFID Data

Real-time data are obtained from RFID (Radio-frequency identification) readers. To gain data, RFID data requires students to place a tag in their student ID card on an RFID reader. RFID readers are located in front of each room, and touching a card to a reader is treated as counting for class attention or authentication to access and exit some certain areas such as library and computer room. The setup of RFID for students to identify themselves and authentication are exemplified in Fig. 2.

Fig2. An RFID setting in front of rooms from the testing site

Upon reading, identification of student is gained and the datum is stored along with time and reader location. RFID data are exemplified in Table 2.

Table 2. An example of data gained from RFID reader on the left and reference of an RFID reader to a location on the right

RFID card	RFID Reader	Time
1011	003	9.00
1012	002	9.00
1015	001	10.15
1014	001	10.05
1011	001	11.03

RFID Reader	Room	Floor	Building
001	Room 04110	1	4
002	Room 05101	1	5
003	Room LAB 1	2	3
004	Room LAB 1	2	3
005	Room Self_Study	3	2

3.2 Activity Ontology

In this paper, we design an ontology [11] to represent knowledge of activity in campus. Hozo ontology editor [12] was used as development tool. The ontology is designed to collect concepts and their relations relevant to students, course, building and activities. The main tree of the ontology is activity concept that has properties such as location, time and person. Sub-concepts of activity are, for example, class_lecturing, lab_studying, self-studying, reading_book, playing_sport and meeting. Some parts of the ontology are shown in Figure 3.

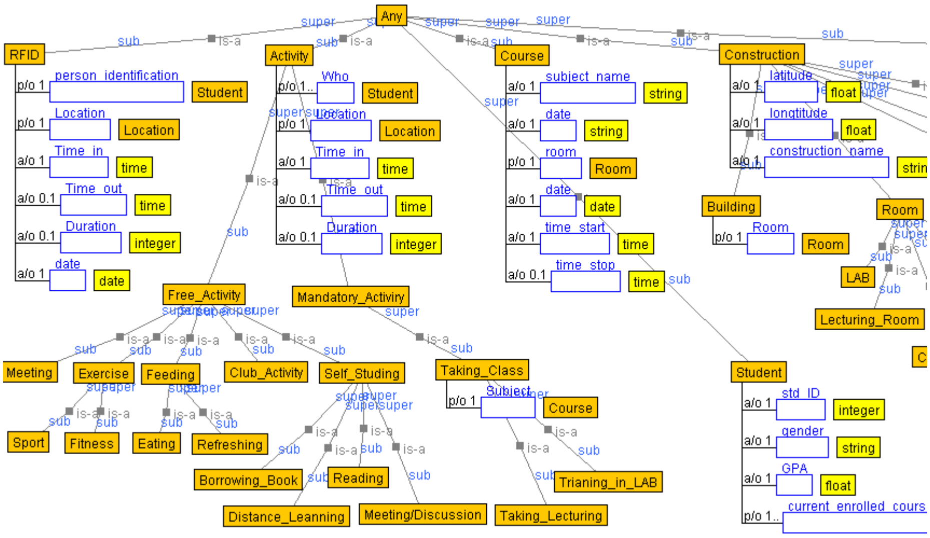

Fig 3. Some parts of Activity Ontology from Hozo editor

In the total, this ontology contains 35 concepts and 26 relations. Once the ontology was completed, it was exported as OWL format [13] file to be used in further process.

3.3 Instantiation

To assign instance to an ontology concept, the two data stored in databases we mentioned above are focused. Database schema is mapped to ontology schema using Ontology Application Management Tool (OAM tool) [7]. To instantiate, we map a database field to OWL class from the ontology according to mapping table shown in Table 3.

Table 3. A mapping table between database field and OWL class

Database		Ontology	
Table	**Column**	**Class/Relation**	**Sub-Class**
Student	Std_id	Student>>Std_id	-
	Std_name	Student>>Std_name	
	Gender	Student>>gender	
Room	Room_name	Room>>construction_name	Self_Study
	Building	Location>>Building	Room
Activity	Activity_name	Activity>>Student	Reading

3.4 Activity Inference

To estimate an activity from instance, inference engine is needed to give a conclusion on the basis of evidence and reasoning. In this work, we applied OAM [7] in which having Jena inference engine [9] plugged in. With the power of OAM, we can create a rule to determine an activity from instances in spreadsheet [10] without knowing syntax of JENA.

Table 4. Inference Rules in table format

Condition			**Activity result**
who	**where**	**When/duration**	
student	lecture_room>> course=student>> enrolled_course	<15 mins_class_start	Taking_Lecture
student	library	>30 minutes	Reading
student	library	<30 minutes	Borrowing_book
student	cafeteria	Between 11:30-13.30	Having_lunch
Student>1 person	meeting_room	>30 minutes	Meeting

From Table 4, the first rule is to check 'if students have their RFID read at the lecture room that is for a course that matches to the course of that student within 15 minutes before the class starting, an activity of *Taking_Lecture* will be assigned to that student'. Next rule is 'if student goes in library for more than 30 minutes, his/her activity will be *Reading*'.

The activity will be assigned to students' activity field in database with time stamp. With an accumulation of activities, an activity profile of students can be created.

3.5 Visualization

Since this work aims to gather activity data of students, displaying data is a must to university personnel to analyze and plan accordingly. We designed two visualizing aspects in this work.

The former is to visualize a graph based on area and time. This visualization is to find areas where are crowded and a time in hour-based for planning several services such as security monitoring and transportation service [3]. The display can be plotted based on time of the day so it can be linked from hour-to-hour to see students' movement. Fig. 4 shows the designed visualization of a crowd in an area. In the visualization, red color indicates highly crowded area while green color shows low crowded area.

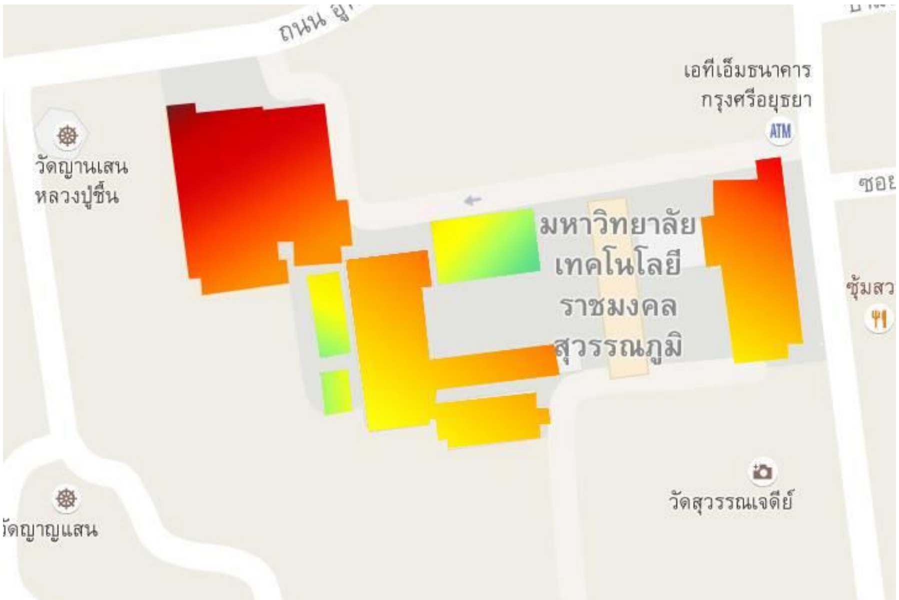

Fig 4. A visualization of crowd in campus from RFID data

The latter visualization is to display activity profile of a student. These data are an accumulation of inferred activities of each student. This visualization can display and sort data in many aspects, such as activity of students in a free time or activity count of students who have GPA more than 3.00. Fig. 5 shows the screen-captured visualization of activity in campus.

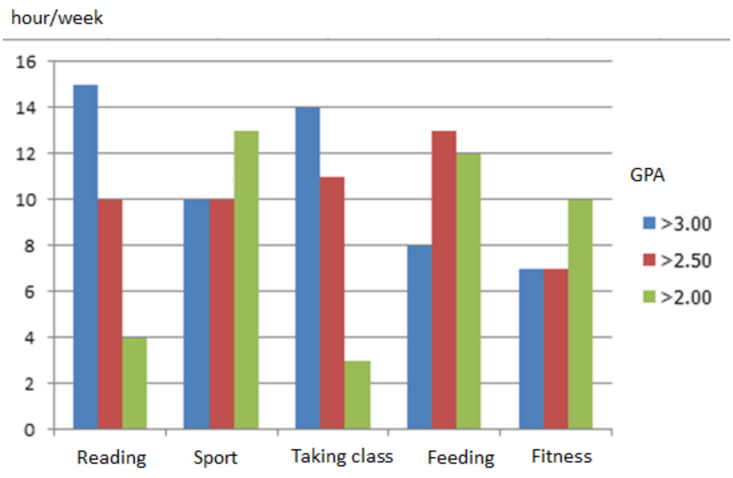

Fig 5. A visualization of activity profiles of students

4 Conclusion and Discussion

This work presents a method to detect students' location in a campus for headcount in an area and activity of student. RFID readers are exploited and located at the fronts of every door of a room to identify students in the area for precision. Ontology was created to represent room type and activity that can happen in a room. With the ontology, activity of students can be inferred using an inference engine embedded in OAM framework based on RFID data and basic data from university. To make data easier for campus management to university staffs, visualization systems are implemented as a visualization to display crowd in a campus area and visualization for student activity.

This work applies on RFID technology in obtaining student data. Thus, we can automatically and precisely identify students and their location. However, in activity recognition, a location and activity are related using ontology and inference techniques to assign activity to students. This method provides us a simple way to gain activity in general. Unfortunately, this method cannot detect a mischievous behavior such as reserve a tutoring room for sleeping and causing other students to lose chance to use the facility for good deeds. Moreover, Some activities such as reading a book in a library should be gathered more in details if a library data about borrowing book can be accessible. With library data, we can infer deeply that students go in library to study more in subjects that related to their current course or not.

To improve our method, we plan to apply more sensor types, such movement sensor and electricity current usage sensor, to detect more minor actions to compose into an activity. We expect this to help us in getting more data in details for mischievous behavior detection for campus management and security control. Furthermore, more basic data from other databases such as library database will be gathered and applied in our method. This should identify details of action that a student conducts.

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