Event Monitoring System of Smart School Laboratory

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***Abstract* – In this paper architecture and basic principles of monitoring system for smart school laboratory is proposed. This smart school laboratory proposed previously by authors is based on technologies of smart environment and multi-agent systems employed to improve comfort, effectiveness and safety during conducting of laboratory work with any technological equipment (e.g., computers, machine tools and so on). Accurate recognition of human activity and the readings of sensors are important for such kind of systems. Event monitoring system in smart school laboratory structure provides correction of fault data readings.**

***Keywords* – Smart Environment, Event Monitoring System, Sensor Networks, Multi-Agent Systems, Fault correction.**

I. Introduction

NOWADAYS UBIQUITOUS computing systems (or pervasive computing systems) are used in the world more and more widely. Such kind of systems create comfortable environment for people. Advantages of ubiquitous computing systems are the result of using not only single control computing centre but some devices (tablets, smartphones, "smart" things etc.) for data processing outside of main computational centre.

The ubiquitous computing systems are successfully employed in "smart" houses for increasing their habitants' comfort, for example, for health caring, services for elderly people, enhancement of comfort in offices and at home [1–7].

Initial data for ubiquitous computing are both data received from various sensors about state of environment and events, in particular, human activities, to decision making aiming to help human beings. Thereby accurate recognition of human activity and the readings of sensors are crucial for systems with ubiquitous computing.

In [8] major activity recognition approaches are considered:

– a) vision-based activity recognition approach [9] (computer vision techniques are used for analyzing visual observations and pattern recognitions)

– b) sensor-based activity recognition approach [10] (sensor network techniques are used for monitoring an actor's behaviour and environment).

On the other hand activity recognition algorithms are considered:

– a) activity recognition algorithms based on machine learning techniques include both supervised and unsupervised learning methods [11];

– b) activity recognition algorithms based on logical representation and reasoning [12].

In this paper an event monitoring system of smart school laboratory (suggested in [13]) is proposed. Event monitoring system is a "borderland" between low-level networks of sensors and hybrid intelligence system of smart school laboratory. Event monitoring system means it be used as for tracking of events occurring in laboratory by the instrumentality of sensor networks.

II. Problem Definition

One of most important parts of smart school laboratory is event monitoring system.

Event monitoring system aims to recognition of events in class and behaviour of students and teacher providing further making decision to help or correct conducting of laboratory work.

The smart school laboratory aims to solve following tasks:

- help teacher to conduct laboratory work with enough large group of students:
  - to inform personally every students about details of work;
  - to advise each student, if necessary;
  - to watch current state of laboratory work as a whole and relating with every student;
  - to estimate results of work of students.
- help student to make required sequence of steps to make laboratory work;
- help student to keep orderliness in work;
- predict and avoid dangerous situations working with equipment;
- store statistics of conducting laboratory work for estimation by teacher and further analysis.

During conducting of laboratory work may be different activity scenarios of system and participants: access of student to laboratory work, absence of student near work place, appearance and disappearance of students and teacher inside room and so on.

Monitoring system must be able to recognize events according to these scenarios.

Source of data for this system is fusion of different sensors including cameras. These initial data may be not enough correct and may be inconsistent.

In this paper we propose architecture and basic principles of such monitoring system, in particular, rule-based method of correction fusion data.

III. Architecture of Smart School Laboratory and Event Monitoring System

Ubiquitous computing systems integrating of human, computer and environment create smart environment for people's working and living surroundings.

Such systems can be used not for work or daily life but for educational institutions — universities or colleges.

In [13] authors proposed the usage of ambient intelligence technologies and multi-agent technology for development of smart school laboratory for conducting of laboratory works in universities and colleges.

This approach to development of computer-aided learning systems is novel. All current existing or developing learning systems are oriented on support of learning process. In contrast to approaches of traditional learning process supporting [14] our system can improve comfort and safety of work in laboratory for students and teacher (helps to conduct or organize but not to learn) and may be collaborate with systems implementing of concept of ubiquitous learning environment (however support of learning process must be provided by our system too).

Structure of hardware for smart laboratory for study of different information technologies is shown in Figure 1. Here are local wire and wireless networks.

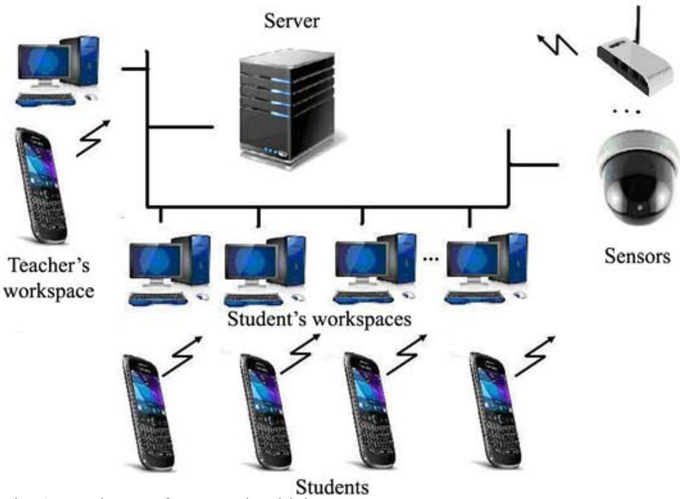

Fig. 1. Hardware of smart school laboratory.

Generally ubiquitous computing systems include monitoring systems for tracking of environment parameters or humans' behavior (in case of help systems with immediate reactions).

Event monitoring systems can be as quite simple systems (rely only on basic computing equipment and networking infrastructure rather than on a rich, sophisticated sensor base and deep integration with existing instrumentation) [15] and rather complex systems [16].

Event monitoring system can use various types of sensors for raw data getting: indoors and outdoors sensors for getting data about environment (temperature, humidity, human presence, human activity etc.) or sensors embedded directly into things which people use (stationery, tableware, clothes etc.) [17, 18].

Architecture of smart school laboratory middleware consists of some subsystems including event monitoring system is shown in Figure 2.

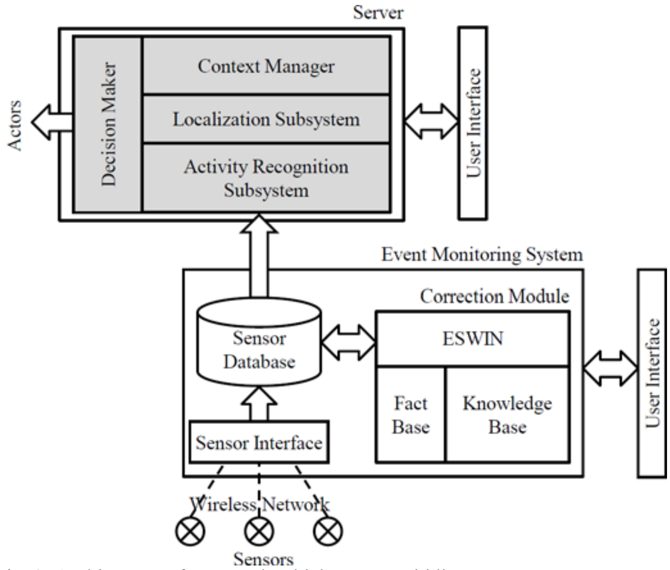

Fig. 2. Architecture of smart school laboratory middleware.

Decision making aims to manage smart objects by actors mean as smart objects computers or computer based equipment (actions with any programs, output of messages and so on), switches (of light, hitting, energy and so on), media projector, smartphones and so on. Decision maker includes knowledge consists of knowledge base for decision making in respect to possible scenarios and context describing current situation.

Context manager uses recognized information to append and change context in which the decision maker, localization and recognition subsystems are solving their tasks.

Localization subsystem aims to recognize, store and track of location of students and teacher, appearance and disappearance of students and teacher inside room.

Activity recognition subsystem aims to recognize images (objects, situations, activity and so on), obtained from different sensors through wireless sensor network. We mean as sensors following devices: video or photo cameras, light and temperature sensors, pressure sensors in chairs, sensors in doors and windows, RFID sensors and so on. Beside as sources of information for this subsystem may be computer or smartphone. Recognition subsystem may be implemented as set of neural networks or as Bayesian network.

Data for recognition and decision making previously processed by corresponding event monitoring system for fault correction.

Event monitoring system consists of sensor database and correction module. Sensor database stores raw sensor data. Correction module implements fault correction before sending sensor database data to server. Sensor data are saved in database via sensor interface from sensors.

Correction module consists of expert shell ESWIN and knowledge and data bases.

ESWIN is expert system shell for designing rule-based expert systems for solving of tasks by interpretation of knowledge bases [19, 20].

Knowledge base of ESWIN is represented by rules and frames. All knowledge base frames possible to divide into two types: frames-classes and frames-examples. The frames-classes forms the basis of knowledge base as far as slots of frames-classes are described objects of application domain and dialogue elements and their possible values, assigned user questions and commentaries.

Slots can be symbol, numerical, linguistic variable or date or time. Frames can be joined to rules and procedures, processing determined events, connected with frames.

During interpreting process of the knowledge base frames-classes can generate frames-examples, intended for the fact description.

Fact base consists of frames-examples. In the fact base frames-examples can be kept only. In general the frame looks as follows:

FRAME (‹frame type›) = ‹frame name›
  ‹slot name 1› {‹comment›} (‹slot type›) [‹slot question›?]:
  (‹value 1›; ‹value 2›; …; ‹value k›)
  …
  ‹slot name n› {‹comment›} (‹slot type›) [‹slot question›?]:
  (‹value 1›; ‹value 2›; …; ‹value m›)
ENDF

The each slot in frames-examples has single value only. A number of slot values are not limited in frames-classes.

In the knowledge base rules are used for the description of relations between objects, events, situations of subject domain. Inference is run on the base relations assigned in rules. It present references to frames and frame slots in rules conditions and conclusions. The rules presentation format looks as follows:

RULE ‹rule number›
  ‹condition 1› … ‹condition m›
DO
  ‹conclusion 1› … ‹conclusion n›
ENDR

In the inference process the fact base is renewed by new facts in case proving of conclusions with use the relations "=" only.

IV. EXPERIMENTAL IMPLEMENTATION OF MONITORING SYSTEM

At the moment events could take place in laboratory are modelled whereby programme scripts (it is planned to use PIR sensors, move sensors, pressure sensors, web-cameras, temperature and light sensors, current sensors, controllers for receiving sensor data in future).

Event models asynchronously generate by client programme scripts in random time intervals. Each event corresponds to own script. Each event model is generated by particular script.

Database was designed for working with events. Database works under control widely used free relational database management system MySQL.

There are several tables in database — one table for every event. Each table keeps list of possible sensor states. Event statements can be edited via web-interface if necessary.

Programme script modelling event origin uses events from the own table list. Information on the occurred event puts into corresponding table in database in chronological order. Moreover there are table with last chronological events for every sensor — event source in database.

Asynchronous work of event generating scripts simulates compulsory noise appearance in sensor readings and therefore simulates corruption sensor readings.

Preliminary processing of getting sensor readings is executed for fault correction. Preliminary processing is executed with knowledge base and backward reasoning rules supporting by expert system shell ESWIN.

Knowledge base includes frames-classes and rules. Knowledge base is basis for resolving of logical reasoning tasks. Rule-based logical reasoning allows correcting conflicting sensor readings.

For example motion sensor reading about no move and light sensor reading about turning light on in laboratory go against each other. Pressure sensor reading about student's absence at his workspace, monitor sensor reading about turning student's monitor on and motion sensor reading about no move at student's workspace is another example of conflict sensor readings.

Information about events received from sensor networks is stored in database tables.

In according to rules in knowledge base the SQL-requests are executed to MySQL-database with sensor readings. SQL-requests are executed over adjusted time intervals. SQL-request results with received sensor readings are put into ESWIN fact base.

Based on fact base and rules in ESWIN knowledge base the correction of possible fault sensor readings executes and revised sensor readings are returned into MySQL-database for following processing.

For example conflict readings from motion sensor, monitor sensor and pressure sensor are corrected according to set of conditions: if monitor sensor and pressure sensor are in "on" state then motion sensor must be in "on" state too.

Correction is caused by next conditions: if pressure sensor readings is "on" (pressure sensor is embedded in student's chair) and student's monitor is on then it is possible to prove that the student is at his workplace and motion sensor gives incorrect readings with confidence coefficient more than 50%.

In propositional logic expressions this statement is formulated as (MonitorSensor on=) ∨ (PressureSensor = on) ⇒ MotionSensor = move.

Based on above expressions following frames-classes and rules are formulated in ESWIN development environment:

Frame=PressureSensor
  State: (on, off)
EndF
Frame=MotionSensor
  State: (move, fix)
EndF
Frame=MonitorSensor
  State: (on, off)
EndF
Rule
  =(PressureSensor. State; on)
  =(MonitorSensor. State; on)
Do
  =(Correction; MotionSensor. State move) 100
EndR

V. CONCLUSION

Proposed smart school laboratory with event monitoring system will provide improvement of organization of conducting students and teacher work; will increase safety using different complex and dangerous equipment.

Such system may provide for teacher opportunity to have 2–3 classes simultaneously using smartphone for real time communication with smart laboratories and students.

Now experimental development and implementation of this architecture is running. As experimental testing area we intend school laboratory for study of any subjects in information technologies, such as, logical programming, object oriented programming, data bases and so on.

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