Problem-solving in Integrated Laboratory using Hackathon Approach

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Abstract:
There is a need to introduce new pedagogy practices to improve the problem-solving skills and critical thinking capabilities of students helping them to execute multidisciplinary projects, thus striving to meet one of the important objectives of the Automation and Robotics program. This proposed paper describes such an activity initiated by an instructional team of 3 faculty members that made students practice the engineering design process using an integrated approach for the selected real-time case study problems during their 6th semester. This integrated approach methodology resulted in the application of the knowledge gained in three different laboratory courses, namely Real-Time Embedded Systems, Object-Oriented Programming languages, and Database Management System practice. The activity was initiated at the commencement of the semester, along with the regular laboratory activities. With a planned schedule, students were made to solve problems, namely, Machine Health Monitoring, Electric power monitoring system, and Sleep Health Monitoring, shortlisted by the faculty team based on the survey done for the latest research topics in the automation area. The time allotted for the activity was two days on an individual basis and was evaluated as a part of their final lab End Semester Assessment scheme. Evaluation of students was done based on well-defined rubrics to test their individual and team-wise skills related to each of the three labs integrated. Here, we present the summarized results of the Integrated activity using Hackathon Approach in the form of the grades achieved and the feedback analysis for the entire class of fifty-five, number of students.

Keywords: multidisciplinary projects, Real-Time Embedded Systems, Object-Oriented Programming, Database Management System, Integrated approach, Hackathon

1. Introduction

In the era of rapid technology advancement, explosive growth in the innovation of technology has a tremendous impact on society. The main objective of the Automation and Robotics program is to make students develop the best competencies in the different fields of engineering so that they are industry-ready. In the department, students study subjects related to Mechanical Engg., Electronics, and Communication, Electrical Engg. and Computer Science Engg. The activity of the integrated approach has accomplished the process of combining various fields of Engineering to solve real-time problems and propose solutions starting from a systematic literature survey using the engineering design methodology for VI sem students of Automation and Robotics program.

The integrated approach used for problem-solving has combined the three different laboratory courses, namely, Real-Time Embedded Systems, Object Oriented Programming languages (OOP's), and Database Management System (DBMS) practices respectively to solve the given multi-disciplinary problem. The students are exposed to the integration technologies required to combine sub-systems belonging to all three disciplines. In the last few decades, the complexity of systems has risen dramatically, leading to the necessity of acquiring the knowledge required to design, implement, and maintain. This paper provides "best practice" paradigms of how these challenges are addressed in "Problem-solving Activity using an integrated approach. This activity has incorporated active learning approaches, using group and team-based approaches. This activity has provided better insights for subjects offered and taught in the curriculum. The integrated programs have a good deal of benefits in terms of project execution skills and developing an in-depth knowledge of a specified problem area and the proposed solution[1,2,3,4]

2. Problem Statements Selected Based On Literature Survey

The generic problem statements, namely, Machine Health Monitoring, Electric Energy Monitoring, and Sleep Health Monitoring, were given to students based on the survey done by the faculty team among the latest research topics. [5]. The detailed problem statements given to students are listed below:

I. The first problem is the machine maintenance problem. Machines are continuously-operated for many hours. Once they break down, it takes a substantial cost to repair them. Detecting symptoms of machine trouble requires a considerable amount of time and technology. Hence it is

difficult to implement. Repairing a machine takes much time; it significantly affects the machine activity rate. Therefore, machines, especially large ones, are required to be free of downtime and capable of planned operation without interruption. To secure such machines, it is necessary to early detect any symptoms of machine trouble by physical examination and analysis of parameters like temperature, vibration, torque, speed, etc. gathered from the machine by installing appropriate sensor modules. There is a need for a data logging facility for each of the parameter and storing on to the database. The further, the algorithm has to be designed for analyzing the data records and make decisions making to give input to the maintenance personnel to take suitable measures to upkeep the machine. The proposed system should ensure predictive maintenance to avoid break down maintenance.

II. The second problem is the detection of a sleep disorder. Sleep disorder caused during night time is one of the very concerning health problems of modern society. It is many times caused by breathing disorders leading to an insufficient supply of oxygen to the heart, causing many heart-related ailments like hypertension, stroke, and atrial fibrillation. Preliminary detection of breathing disorders can save people from such heart diseases. The gold-standard test, being used for sleep disorder detection, is Polysomnography (PSG), which is a very sophisticated and costly technique. Also, the patient needs to be in the sleep lab setup continuously for a minimum of 8 hours during the night. One way of detecting the disorder is through the study of physiological parameters like Electrocardiogram (ECG), EEG, EMG, EOG, blood pressure, pulse rate, temperature for about 8 hours of sleep. The values of these parameters lie in the specified ranges for a normal person. For a patient affected with the sleep disorder, the parameter values are going to change from the normal ranges based on its severity level. There is a need to decide on the optimized set of parameters that can be studied to detect sleep disorders. Hence the need is to develop a data acquisition system for gathering the necessary physiological parameters for the entire night that can be stored on to the database. Further, an algorithm can be developed for processing data records in offline mode.

III. The third problem discusses the issue of management of water supply across the KLE Tech campus, which has many bore-wells, generators used for 13 academic blocks, and four hostel buildings. There is a problem of power shut down; power fluctuation and interruption of power supply. There is a need to monitor the electric power consumption campus-wide. The proposed system needs to have a data logging facility whenever there is an interruption in the power supply using the database. Further, an algorithm can be developed to analyze the recorded data and estimate the power consumption building-wise and analyze the problems of power shut down, power fluctuation, and interrupted power supply that occurs thought the day.

3. Design and Implementation

The activity was initiated at the commencement of the semester, along with the regular laboratory courses. The activity is conducted according to a planned schedule, based on which introduction to the activity, the guidelines, the scope, and expectations were discussed as the first stage. The basic concepts related to the three laboratory courses were taught during the regular lab sessions for 8-weeks involving demonstration, exercises, and structured queries, which was a prerequisite for the planned activity. The class strength of 55 students was divided into teams of 6 students, and each team was assigned a specific problem statement. Thus the integrated approach aimed at proposing solutions for real-time case studies by the student teams of Automation and Robotics program during their 6th semester[8]. The activity was conducted team-wise from the literature survey up to review of progress on the analysis of the problem as per the schedule planned for 4 hours per week. Later, students were asked to work on an individual basis to propose a unique solution for the selected problem. Further, the proposed solution was implemented by students in the Hackathon event on an individual basis. As the first part of the activity was conducted in teams, the collaborated efforts within the team helped them in analyzing the problem with enthusiasm.

The hackathon event was planned and conducted for two working days for 7-8 hours at a continuous stretch. During the event, the students were asked to build their proposed solutions on an individual basis from scratch. The activity aimed at guiding the students to solve the given problem starting from data acquisition using sensors, use of real-time hardware for processing of the input data, data logging on to a SQL database, and finally an intelligent decision making with algorithms developed using object-oriented programming language.

The Engineering design process was followed in the activity to analyze the problem thoroughly and arrive at an efficient solution. Under the first stage of the activity, students were made to analyze the chosen problem with a set of collected requirements gathered from the state of art literature survey[9], The specification obtained after the requirement analysis resulted in predefined behavioral assumptions which were verified before the actual implementation using system modeling language (SysML). The use of software tools for help in presenting the critical analysis of the problem[10], which is highly convincing and enabled better understanding. The complexity of the problem is resolved using System Modeling Language (SysML) with the help of standard models such as the USE-CASE diagram, Requirement Diagram, Activity Diagram, Sequence chart, and statecharts diagrams respectively[10]. The proposed techniques can be easily realized using the software tools that prove to be very beneficial in analyzing the problem as well as the solution

in every detail. The techniques help to understand the intricate details of each of the steps in problem-solving, before developing the final algorithm. The advantage is that the approach can be adopted for solving any real-world problem from scratch, which is an important ability of a budding engineer.

The sample diagrams such as USE-CASE, Requirements Diagram, and Sequence Diagram are shown in Figure 1, Figure 2, and Figure 3, respectively, for the problem on Sleep Health Monitoring.

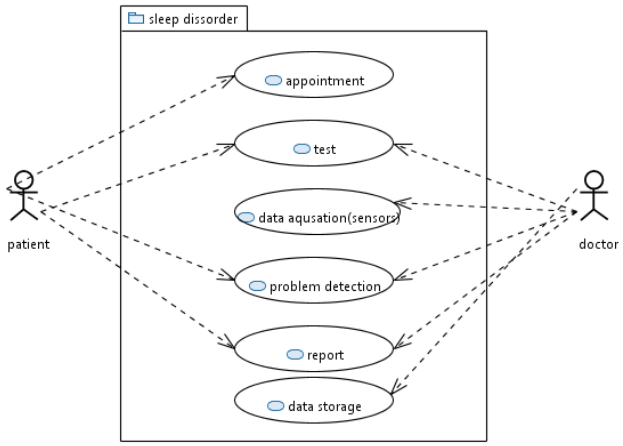

Figure 1. Sample SysML diagrams- USE-CASE

The requirement diagram deals with the requirement analysis of the problem in-depth and also the performance of the proposed solution, and further, the built system can be rated against the required specifications. The pictorial representation of the requirement analysis is quite convincing for the students.

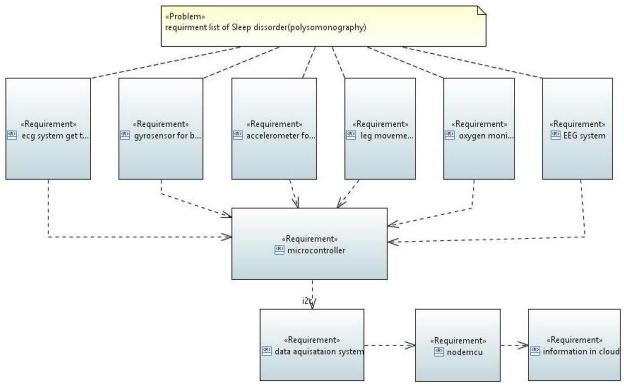

Figure 2 Sample Requirement diagram

The sample sequence diagram shown in Figure 3 provides the stepwise approach to solving the problem, which helps in ensuring the smoother development of the algorithmic code. The approach proved to be very useful and easy for students to analyze and present the solution using specialized software tools discussed above. This was an important step to refine their programming and analytical skills using the extensive use of software tools for the purpose[5,6].

Peer learning ensured simplification of the learning for every member of the team while studying the survey papers and analyzing the selected problem. Students were able to build a morphological chart explaining the means of implementation of each of the subsystems for the proposed solution.

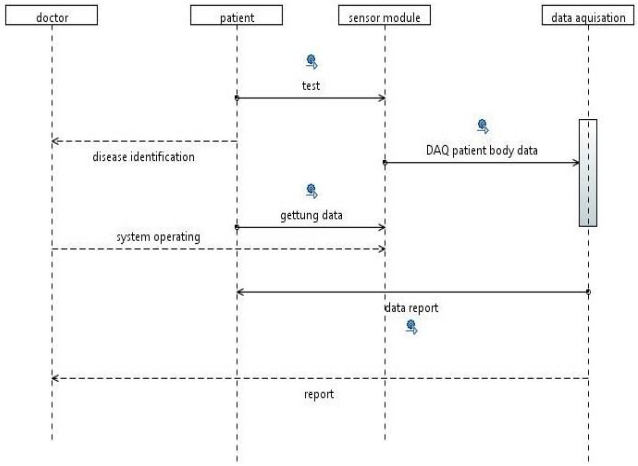

Figure 3 Sample Sequence diagram

As per the objectives of the Real-Time Embedded System course, students need to acquire knowledge in the areas. Namely, the capturing of real-time data, deciding on the selection criteria for sensors, mounting of sensors, power-management strategies, and interfacing of real-time target hardware. The student needs to understand the requirements of programming and storing the captured data on to a storage device for future usage in offline processing and online gathering of parameters from sensors through a real-time target. To address these requirements and build the solution, the students had the choice for materials and methods under each category, for sensing, signal conditioning, processing, storing, and lastly, interfacing with computers for access to high-end tools for intelligent decision making and database management.

The relational database used in the proposed solution provides support for efficient data logging. The information collected through requirement analysis and the data-acquisition from sensors was used by the student to check the dependencies between the identified entities by the E-R diagrams.SQL engine is used to create the table and to write queries. The students have been experimenting the object-oriented programming techniques, namely, C++, Java, and python successfully. The front end GUI design that enabled the user's interaction and the intelligent decision making for the data captured in the database system was implemented using object-oriented programming language[7-11]. Thus the extensive use of tools enables every student in a team to understand the

stages of the design process, analyze the problem as well solution.

The generic block diagram of an example inter-disciplinary system is as shown in Figure 4.The prototype models having the essential blocks built by student teams, as shown in Figure 4, that are developed under each of the problems. Hence the representation of the proposed solution is taken to be a control system programmed for monitoring and control problems.

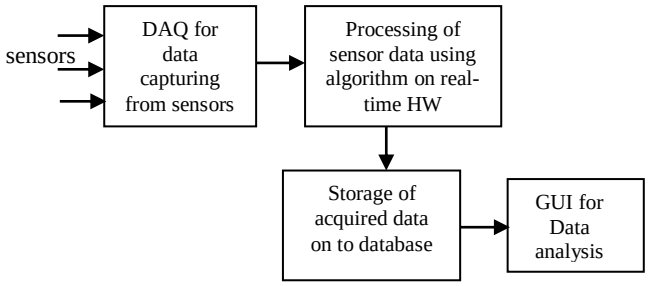

Figure 4. A generic system block diagram for the solution of selected problem statements

The multi-methodology approach based on the "pick and mix" method was followed by students, in which the most appropriate methods for data acquisition, data logging, and decision making were chosen to fit the problem rather than following a single methodology. The prototypes developed at the end of the hackathon event were interesting. In one of the solutions developed on machine health monitoring, the physical model of sensor network was built using temperature and vibration sensors installed at required places on a shop-floor machine and the sensor data was processed in real-time using the TIVA C series microcontroller and analysis graphs were presented using the graphical user interface. For the second problem on sleep health monitoring, students had gathered sensor data using a pulse oximeter, motion sensor, and heartbeat sensor installed on the body for a set of adults during sleep. The analysis of sensor data was done in off-line mode on a desktop computer to provide a decision based on number of sleep apnea events that occurred during sleep and infer whether the person is a normal being or the one affected with apnea. The solution provided the analysis of graphs of physiological parameters tapped from the body.The real challenge for students was to satisfy the objectives of each of the integrated laboratories in a justifying manner.The activity involved team-based efforts and thus promoted peer learning. The weaker students were motivated to perform the tasks assigned to them efficiently [11].

4.0 Assessment

During the review process, the challenge was to measure the attainment of objectives of each of the laboratories, namely, Real-Time Embedded System, OOPS, and Database Management Lab. Students were tested on the integration technologies used under the project solution. This was achieved by following the well-defined rubrics developed for each phase of the evaluation process. The time slots planned for review could accommodate interactions of faculty mentors with students regularly up to the time of the start of Hackathon event. There were four review meetings along with intermediate evaluation, conducted for follow up of progress done by student teams. Intermediate grading was also done for 30% of the allotted marks. Time allotted for implementation of the finalized solution was two days through the Hackathon event, i.e. a total of 14 hours on an individual basis and was evaluated as a part of their final lab End Semester Assessment (ESA) grading procedures. Evaluation of students was based on well-defined rubrics used for testing their individual and team-wise skills related to each of the laboratory for the remaining 70% of the allotted marks in the respective laboratories[8-11].

5.0 RESULTS AND FEEDBACK

Students presented the analysis of the problem and the solution, in detail satisfactorily, and could address every issue using the survey data. Analysis of the results achieved by students was quite encouraging, as 75% of students completed the development of the solutions within the stipulated time satisfactorily, whereas 15% of them ended with partial results as shown in Figure 3. Grading of students was done using the rubrics on the survey of the literature, algorithm design, execution time, and analytical ability. The oral feedback and the enthusiastic participation of students in the hackathon event were encouraging. The knowledge gained by students on the integration technologies was quite satisfactory, as evident from the grades scored.The student's feedback on the activity was captured through a questionnaire, and it revealed that the activity helped them in enhancing their skills related to problem-solving ability in a real-time scenario along with other skills, namely, time management, programming, debugging and troubleshooting as shown in Table 1.

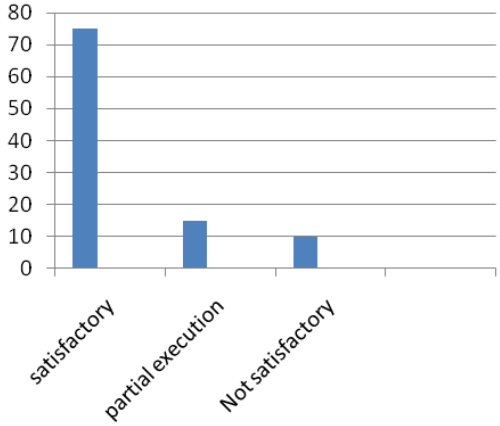

Figure3 Analysis of Student feedback

Table 1.0: Summary Feedback collected through Questionnaire

Factors measured based on Feedback and performance	Attributes			
	Strongly agree	Agree	Disagree	Strongly disagree
Team work	52	30	14	4
Problem solving skills	45	52	3	0
Extent of achievement activity	55	25	15	5
Time duration of activity	60	30	5	5
Skill development	50	35	10	0
Communication skills	60	35	5	0
Autonomous learning	50	20	15	5

The feedback received and the results attained by students was quite motivating for the involved faculty members to refine the activity. The evaluation conducted by the faculty team in a collaborated manner helped the analysis of students' performance critically as well to give them the feedback for improvement, which proved very crucial, while students solved real-time case studies. Hence the outcomes of the proposed activity addressed the important requirements under the majority of the graduate attributes

6. Conclusion

The analysis of feedback and the performance of students could boost the morale of the faculty members involved in conducting the activity. Students understood the intricacies of integration technologies involving hardware and software elements while building the solution for the stated problem, which is essential for the students of the interdisciplinary branch. The experience gained by students through the proposed problem-solving approach will surely help them in executing the projects in higher semesters. Students experienced the advantage of peer- learning in the team as well as test their solutions through Hackathon event. It was a unique and challenging experience for the faculty members to guide the students to solve problems mimicking real-time case studies.The faculty members involved got motivated through students' volunteered participation and demonstration skills. The activity could address the majority of the engineering graduate attributes. The need for refining the activity in terms of changes to be made in team size and allotment of extra time slots was felt for the smooth conduction of the activity, which will be taken up as an improved measure.

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