San Jacinto College and University of Houston – Clear Lake

Final Report

Team UHCL-SJCN

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An isomorphic Marzano approach to project and classroom management in the NASA Swarmathon

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***Abstract*— This paper describes an educational model used for collaboration between institutions and academic programs which is isomorphic to industry for swarming robotics. This is achieved using Marzano Taxonomy and a systems engineering framework along with linked classes and clubs. The resulting algorithms in ROS, Arduino, and Scilab/Matlab are able to generate both simulation and physical robotic motions. The algorithms are designed for input from differential equations and trajectory points, which are simulated and optimized on the physical swarmie bot.**

Keywords- swarm robotics, systems engineering, Marzano Taxonomy

I. INTRODUCTION

The primary goal of our work is to increase student success. To accomplish this, two isomorphic structures are implemented, as shown in figure 1. Student success, as defined by the college Student Enhancement Programs in accreditation, is to be able to conduct literature review research towards knowledge utilization and to be successful at the current and next level of study [8]. The community college students shall be prepared to enter courses at a partner university while the university students shall be prepared to enter graduate school or industry. The opportunities at NASA are especially significant since they provide a greater than five to one return on investment in research so have greater potential to solve meaningful problems [6].

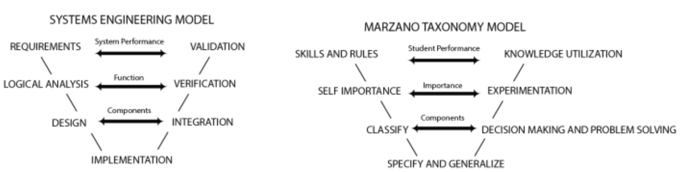

Figure 1: Marzano Taxonomy as an isomorphic structure to the systems engineering process.

The systems approach allows formal and informal contributions so that students in officially linked classes as well as casual clubs are may provide input into the project. Students are generally assigned to either a hardware or software team and work towards common goals.

Marzano Taxonomy has been used in classroom and assessment structure where the structure of the course is set to move from basic repetition to knowledge utilization through a scaffolding of intellectual steps [4,5]. The natural progression from the requirement to the verification of knowledge lends itself to an isomorphic structure to the systems engineering process, which has not been previously done.

Previous collaborative research has been shown to be successful between the two colleges [1,7]. Current research in the college has shown hands-on and industry-based activities to be successful both in the classroom as well as in extra-curricular activities [3]. Marzano-based STEM courses in San Jacinto College have been shown in pilots to increase student success by 9% when implemented by full-time faculty without additional cost the college, as reported in the program review.

II. METHODS

A. Educational Approach

The education of a student has been divided into four fields for analysis, as shown in figure 2. They are divided into formal and informal education. Formal education indicates that something will be used as course grades and the overall grade of the course will be placed on a transcript. Informal learning can be done outside the normal classroom and is not graded formally on a transcript. A formal setting for education is a classroom or a computer lab with an instructor or lesson leader. An informal setting for education is where there is no formal leader and the students contribute equally.

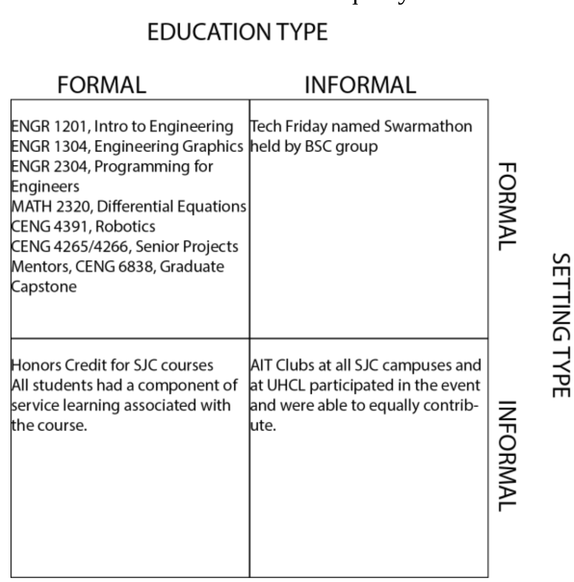

Figure 2: Modes of learning as formal and informal combinations.

The formal education of a student in a formal setting at the top left indicates that the student will be in a classroom for the course and they will receive credit on their transcript. The SJC courses have been identified as honors courses and are directly linked to the courses. Likewise, the robotics course and senior projects courses at UHCL have been identified as specialized courses and linked to the project. This allows students to receive direct credit for their contribution to the team. Several courses have been linked for the Spring 2016 semester and will be again linked in the Fall 2016 and Spring 2017 semesters. Student learning outcomes consistent with the taxonomy have been created, as shown below.

HONORS LEARNING OUTCOMES:

A. Design a short-term project from preliminary idea to completion.
B. Report on and describe the process and results of a project or experiment, arriving at an inference.
C. Describe the development of a project in reasonably satisfactory prose.
D. Identify the logical relationships among components of any event, project, or system.
E. Understand the relationships of components of a system or process.

The honors learning outcomes have been coupled with an honors project outline and grading structure so that the students understand what is expected of them. The more advanced students at the university are given the task of service learning so that they are able to contribute to the knowledge gaining of the students at the junior college while the junior college students are given the task of outreach and service learning to recruit from the intermediate and high schools. The inclusion of the project beyond the regular coursework requires independent and group learning outside of the course, and thus is informal learning towards a formal credit.

The informal learning is also divided into formal and informal settings. The formal setting example here is the Tech Friday held on February 19, 2016 at UHCL with the BSC group. The registration of 45 people was filled to capacity and over 90% of the participant responses were of interest in moving further into ROS. This informal learning event was held in a classroom and instructed by a student senior in the robotics course and assisted by six instructors and four student mentors. This type of mass tutoring allows students to learn new skills in one afternoon from peers in a setting where they can ask questions of any level. These events are open to the public and are have students from high schools and colleges.

The informal learning in an informal setting is driven by clubs. At all three SJC campuses and at UHCL, there is an AI-Tech Club. These students meet at least once per week at each campus and work on projects. The NASA Swarmathon has been a major project that they have undertaken. Particularly, the AIT members post data and pictures and create suggestions for motion patterns. These students provide critical links between the schools since they often attend meetings at more than one campus and provide outreach to local schools on a regular basis.

The division of education into formal and informal categories along with the systems approach allows for the emergence of large scale project management for the project. Peer mentoring from the BSC mentors allows students to get tutoring in courses where they may be struggling so that they can be supported in their studies and the project. The complete list of courses and the responsibilities of each course is listed in Appendix A along with the student contributions.

B. Algorithmic Approach

The two primary objectives in the algorithm design are to work with hardware and software effectively. Hardware construction and measurements can be done under the student learning outcomes of the introduction to engineering and engineering graphics courses while the programming and motion planning can be done in math and programming courses. Clubs have the opportunity to contribute on either side. Another contribution to the project comes from the Swarmathon organizers at University of New Mexico and NASA, as well as the informational forums online.

The BSC group has been charged with holding informational lessons through Tech Fridays and the STEM Challenge to provide students basic knowledge of ROS. This allows structured lessons to be taught directly from the students themselves. In here, they learn how to run the basic simulations and look at sensory data and get a turtlebot to move along a path. The BSC peer mentors also provides student tutoring at both colleges in STEM courses to help students succeed in their regular coursework as well as to help answer technical questions.

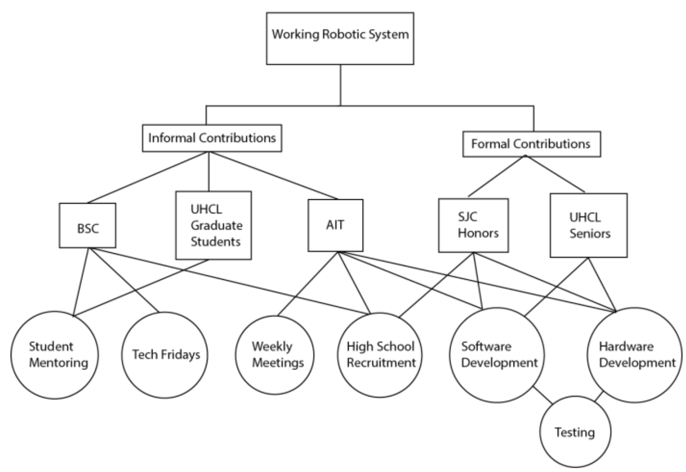

Figure 3: Work breakdown structure showing how the students worked towards a working robotic system.

The seniors in the capstone class have requirements that the mobility algorithm have the option to input motion through differential equations and trajectory locations. The initial trajectory location mobility algorithm divided the total square into three rectangles and had each bot run a zig-zag pattern along the rectangle. This works in the simulation since the orientation of the rectangle is known, though not in the physical bot since the orientation of the rectangular grid is not directly known. This algorithm along with the known issue is then handed to the other students.

Identify applicable sponsor/s here. *(sponsors)*

The students in the robotics course heavily focus on making algorithms and as a result begin adding counting algorithms for the April Tags and providing technical support to the algorithmic development of other teams. The two team leads with final approval rights come from the robotics course and the senior design course.

The programming for engineers and differential equations courses at SJC provide the background algorithms for overall path research. Here, the students work with Scilab/Matlab algorithms and Arduino code in the programming course, which is directly applicable to the project. The resulting Scilab codes provide trajectory output commands for the code that the senior design project group has created. The outputs are already formatted for input into the ROS simulation for testing. The experimental tests are run by the software teams on the simulation environment and are translated to the physical upload. The calibration tests were done by collectives of students, in which data and communication is kept in 'Slack'.

III. Experiments

The trajectory location approach allows paths to be tested quickly if trajectory locations are carefully typed into the simulation. The Scilab algorithm allows trajectory locations to be created from differential equations and simple analytical geometry and put in the correct format for the ROS algorithm as long as the resulting CSV has the commas removed in a word editing program. The experimentation is then able to be done on both the hardware as well as the software.

The software trajectory experiments using a simple zig-zag pattern is highly effective in the plane where the orientation of the rectangle is known. The initial hardware experimentation shows that there are strong differences between the simulation and the hardware and that further calibration is necessary. Thus, the group has focused on trajectories of circles, as shown in figure 4. These simple shapes allow for the calibration to be done more clearly.

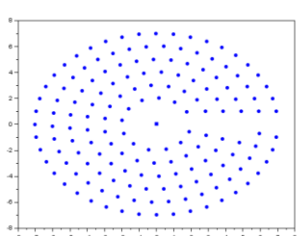

Figure 4: Circular path coordinates created in Scilab and output in format for input to the Mobility.cpp algorithm in ROS.

The experiments on the hardware show differences of greater than one meter when using the method described in [2] to calibrate position. The Aduino code for wheel diameter has been changed to 11mm to account for the compression when the wheel is driving, which brings the correcting factor to less than one meter.

Further calibration brings the code prepared for the challenge. Experimentation and results continued up until the night of submission and beyond. Further progress will focus on both equation-driven as well as coordinate-driven approaches.

IV. Results

The experiments on the simulation environment indicate that several path patterns would be effective in non-clustered distributions. The clustered distribution indicates the need for a counting function for the April tags, a task for the senior group. The simulation environment allows for the bot to be programmed and collect large numbers of tags.

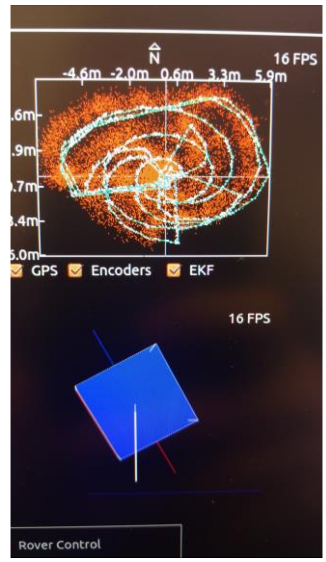

Figure 5: The bot successfully drives the desired path in both the simulation environment and the physical environment.

The direct change on the Arduino code did not bring the bot to within statistically significant behavior to ensure that tags would be counted to a large number. Further investigations will occur until and after the challenge.

V. Conclusion

The classroom structure for Marzano Taxonomy and the parallel activities outside the classroom are a success. The courses with tutoring coupled with external opportunities have strong success rates and strong participation in extra-curricular activity. The hardware and software management into formal and informal divisions allows for participation and input at all levels while having experienced students continually lead the less experienced. The initial goal of the project was to include 50 students. Formally, 49 students signed up and more than 30 more participated in events and meetings without formally signing up.

Simulation results are effective, showing ability to get tags with the predetermined paths effectively the uniform distribution. Implementation of a heap function from a BSC mentor allowed the bot to identify the cluster for returning. The correctly finds and counts tags, though is still working to find the center consistently.

Future research includes the further development of the algorithm to accept both equation and pre-determined path sets for testing. In this way, both probabilistic and deterministic algorithms can be implemented by students with relatively little knowledge of ROS. Current competition with University of Houston Main Campus allowed for the teams to find faults in the code and discuss changes, so future competition will continue.

ACKNOWLEDGMENT

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Appendix A: Contributions

Table 1: UHCL and SJC classes linked to the Swarmathon

UHCL	SJC
CENG 4391: ROS	ENGR 1201: Intro to Engineering
CENG 4265: Senior Design 1	ENGR 1304: Engineering Graphics
CENG 4266: Senior Design 2	ENGR 2304: Programming for Engineers
	MATH 2320: Differential Equations

Table 2: Student and general role in the Swarmathon. Note that *[m] indicates the student is a mentor, *[s] indicates senior

Name	College	Role
Darshan Patel *[s]	UHCL	Hardware
Muhammad Khan*[s]	UHCL	Hardware
Jahan Khoja *[s]	UHCL	Hardware
Alyssa Casas *[s]	UHCL	Hardware
Charles Kendrick *[s]	UHCL	Software
Chris Huerta	UHCL	Software
Melissa Bell *[m]	UHCL	Software
Aya Fadel *[m]	UHCL	Software
Austin Hill	UHCL	Software
Miguel Rosales *[m]	UHCL	Software
Andrew Aycoth	UHCL	Software
José Velazco *[m]	UHCL	Software
Kasey Clark	UHCL	Software

Name	College	Role
Miguel Ramirez	SJC AIT	Hardware
Eugenio Garate	SJC AIT	Hardware
Tai Tran	SJC AIT	Hardware
Jeremy Penny	UHCL AIT	Hardware
Joshua Lewis	UHCL AIT	Hardware
Kevin Fuentes *[m]	SJC AIT	Software
Chris Stewart	SJC AIT	Software
Pedro Rangel	SJC AIT	Software
Phillip Victor	UHCL AIT	Software
Greg Hemenway *[m]	UHCL	Software

Name	College	Role
Elizabeth Dimopoulos	SJC	Hardware
Jose Alvarez	SJC	Hardware
Atai Trevino	SJC	Hardware
Bernardo Ramos	SJC	Hardware
Santiago Orozco	SJC	Hardware
Jesse Munoz	SJC	Hardware
Hector Estrada	SJC	Hardware
Kevin Sagastegui	SJC	Hardware
Luis Pantoja	SJC	Hardware
jorje reyes	SJC	Hardware
Julio Herrera Jr.	SJC	Hardware
Josue Otero	SJC	Hardware
Laura Delgadillo	SJC	Hardware
Eddie Cabrera	SJC	Hardware
Samuel Norman	SJC	Hardware
Luis Zavala	SJC	Hardware
Travis Ketchum Alvarez	SJC	Software
Amalia Pena	SJC	Software
Dat Tran	SJC	Software
Salvador Cuevas	SJC	Software
Brianna Nicole Siller	SJC	Software
David Garcia *[m]	SJC	Software
David Torres	SJC	Software
joaquin gonzalez	SJC	Software
Adriel Arias	SJC	Software
Josue Zuniga	SJC	Software