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The Role of Underwater Robotics Competitions in Shaping Postgraduate Research and Industry

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ABSTRACT

This paper investigates the impact of unconventional learning experiences, such as participation in underwater robotics competitions, on the research productivity of postgraduate students after graduation. These experiences provide students with valuable training and hands-on practice in a competitive environment. We argue that such experiences are not only beneficial for research but also for developing highly skilled graduates in hardware and software engineering. Furthermore, these competitions can foster an entrepreneurial spirit, motivating graduates to launch their own Small and Medium Enterprises (SMEs) in the field of underwater robotics. The paper showcases examples of impactful postgraduate research directly influenced by such experiences, alongside successful startups founded by competition alumni.

Key-words: Unofficial, underwater, robotics, start-ups, education

I. INTRODUCTION

The demand for industrial units in Egypt has led to significant growth in feeder industries. Each year, these industries recruit engineers specializing in a range of fields such as Embedded Software Engineering, IT Engineering, Technical Training, Software Application Development, Embedded SW Testing and Validation, C++, C and Java Plugins Tooling Engineering, Principal Software Engineering, and Algorithm Development for Autonomous Vehicles.

With a population of approximately 110 million people, a prominent position in Middle Eastern politics, and a strategic location spanning Europe, Asia, and Africa, the Egyptian market holds great importance. Each month, the market presents around 5000 engineering positions, with a notable focus on embedded hardware and software engineers. This demand is driven by the corresponding growth of international and national feeder industrial firms, resulting in a 30% annual increase in employment opportunities over the past three years.

The early studies in the late 90's, showed the erg need for spreading the knowledge of informatics and mechatronics to non-university and university students. As a result, The Arab Academy for Science, Technology and Maritime Transport established the Regional Informatics Centre [1] in 2002. The centre has 3 main goals

- gathering and encouraging talented youngsters and youth;
- attracting their attention to the importance of **informatics, mechatronics, and robotics**,

- orientating their interest towards channels that are advantageous to the community in terms of development and inventiveness.

To achieve these goals, the center began by providing a competitive environment for pre-university students through programming and robotics workshops and training courses. The main challenge is to participate in national and international competitions.

In 2012, the center took a significant step by organizing the local Egyptian competition for underwater robotics, known as the Egypt MATE ROV competition. The competition has two main categories: 1) Explorers for university students, 2) Rangers for pre-university students.

Students must consider themselves as "entrepreneurs" and transform their teams into businesses that create, market, and sell "products" in order to compete in the MATE competition. In addition to designing ROVs, students will apply what they've learned in class about physics, arithmetic, electronics, and engineering to real-world difficulties in the marine industry. Mentors (teachers, parents, and working professionals) are expected to confine their contributions to educational and inspirational roles, and are encouraged to concentrate on the benefits of the learning process rather than submit technical papers, poster displays, and engineering presentations to be presented to working experts who will serve as competition judges.

II. Underwater Robotics Research

The post graduate students who participated in this competition and other competition related to such area resulted in successful research and development and start-ups. For example, a well research was done in Unmanned Underwater Vehicles (UUVs. The work focuses on designing a nonlinear controller for the purpose of controlling MIMO Autonomous Underwater Vehicle (AUV) in all degrees of freedom (DOF). The appropriate and efficient control system design is achieved by formulating an inverse kinematic model for the AUV, using Fuzzy Logic rule base for online tuning of the PID parameter, and using Quaternions in rotations observation and control. The presented vehicle configuration allow the AUV to have a fully-actuated 6 DOF. This work is a simulation based where a rigid body dynamic model and underwater environment hydrodynamic model are formulated and utilized in this study to validate the control design.

The cascaded double loop control structure is presented in this work. It proves its high capability to make the system achieve the reference with minimum time response besides the attenuating of environment Gaussian disturbances rapidly. The inner and outer loops are designed to control both speed and position of the AUV, respectively. Regarding the Fuzzy Logic design, a Mamdani fuzzy rules are used to tune the parameters of the PID and the outputs membership functions are selected as Gaussian and Sigmoid functions to give better performance and response in the non-linear system.

The Quaternions mathematics are utilized in the control design to give wide grasp of control over AUV rotations in the 3D. Since one of the main advantages of the Quaternions that it overcomes the singularity took place when using Euler rotations method which is called Gimbal Lock phenomenon.

Several case study scenarios are conducted to validate the control system design with the utilization of the dynamic model of the AUV and underwater environment. Each case study has different kind of complex trajectory to demonstrate the performance of the controller. Beside 2 case studies that demonstrate the Gimbal lock phenomena and the performance of the Quaternions control. A conducted case study that shows the capability of control either velocity or position independently. A Gaussian noise disturbance are injected to the system and the time response results of the controller are presented. [2],[3]

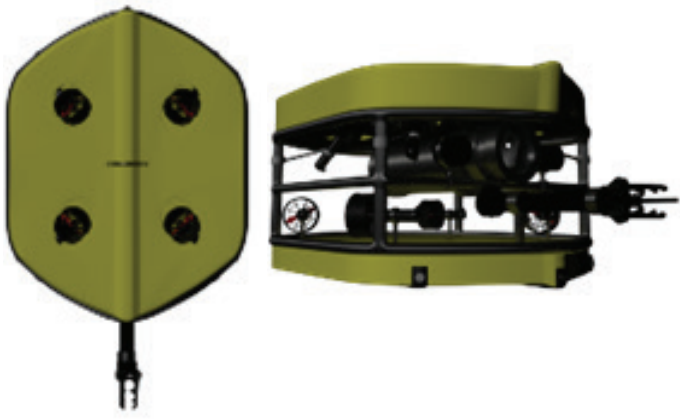

Figure 1 AUV body configuration

III. Mecanum Wheeled Chair

Another research was done also with another postgraduate student from AASTMT for autonomous wheeled mobile robots. A novel navigational system for handicapped wheeled chairs with mecanum wheels. The wheels provide a flexible mobility represented with its 3DOF (Three Degrees Of Freedom) ability of mobility. The chair provides assistance for the user according to his/her medical situation. The user can control the chair using a joystick or vocal command signals.

The main contribution of this work is defined by the platform kinematics, dynamics modeling and its navigational control system. The mobile platform is kinematically and dynamically modelled and tested on the simulation level to illustrate its performance. The chair is able to navigate in a smart environment, for example, in handicapped house with a known map. The navigation system implemented on the chair will provide position, collision avoidance and local navigation behaviours. The environment is configured as nodes and the chair should follow a series of nodes to reach the desired room. Firstly, a node generator will propose a sequence of nodes, which must be reached respectively. The node generator is created using neural network algorithms. Secondly, the position control will drive from one node to another assuming reference trajectory of a straight line between each two nodes. Thirdly, the fusion between position control and collision avoidance will enable each behaviour according to the situation. The navigational control system is implemented on a hardware prototype and the experimental results are illustrated to show the acceptable performance of the whole system. [4],[5]

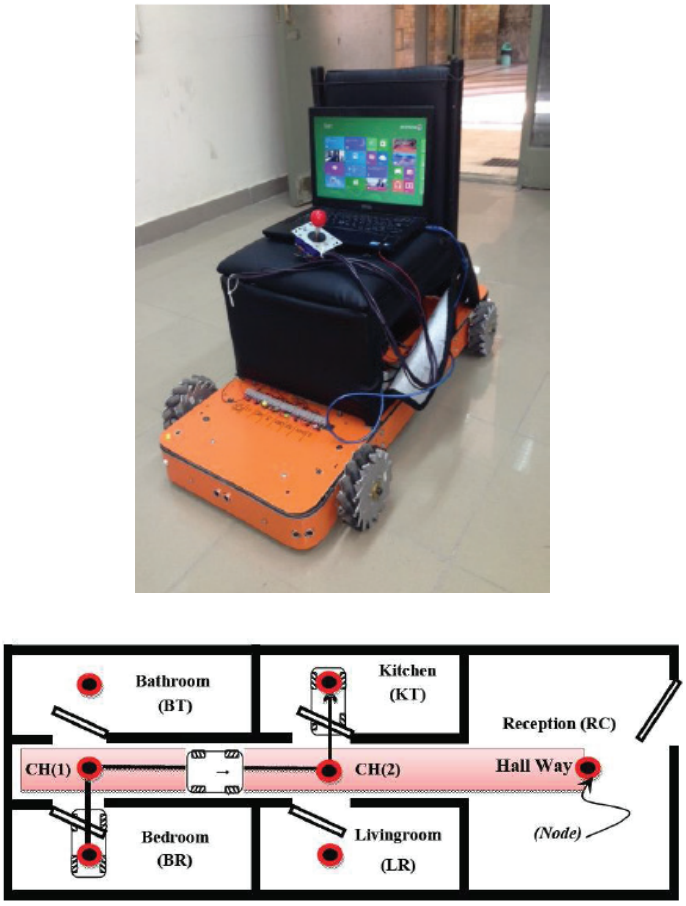

Figure 2 Autonomous wheeled chair for special needs (Left: prototype, Right: Navigation map)

IV. Successful Startup

In 2018, The International winners wfor the Underwater ROV competition were a team named “Vortex”. The members were mixed students from AASTMT and Alexandria University. Some of the team members decided to establish a startup for training and research and development of ROV. The members started by joining the rally of entrepreneurs which is running under the Center of Entrepreneurship in AASTMT [6]. The startup was established officially in 20218 and the first micro ROV for inspection was introduced in 2019.

Figure 3 The 2018 winning ROV: V-Drax

The company offers certified training for school and university student. In addition to inspection and training ROV kits like V-Drax, Swift AUV and V-ray. Vortex Robotics Academy succeeded to be the first ROV Manufacturer in the Middle East with its fully created designs and technology to start its renovation in the underwater world and provide innovative solutions for the marine industry. [7]

V. Conclusions

The effect of unofficial education presented by the training and participation in competitive environments provided by the Regional Informatics Center in AASTMT, result a skilled graduated from engineering and computer science faculties. These graduates shown their outstanding skilled researchers and outstanding graduates working in large industrial firms in Egypt and other countries as well. The impact of such education resulted startups that impacted the Egyptian underwater ROV services for gas and oil pipe inspection and training as well.

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Biography

Dr. Ahmed El Shenawy, Dean of the Regional Informatics Center, at the Arab Academy for Science, Technology and Maritime Transport, in Alexandria Egypt. He is also a professor in the College of Engineering and Technology. He had received his doctoral degree in April 2010 as Dr.rar,nat, Doctor of Natural Science in the field of robotics systems from University of Mannheim, in Germany. In addition, he gained his Bacholar, Master Degrees from the Arab Academy for science, technology in 1999, 2002 , respectively. His research interests are Wheeled mobile robots, manipulator robotics systems , medical robotics.