The Need for a Systemic Approach to Specifying a Robotics Tutorial

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Abstract: - The objective of this paper is to underscore the advantages of employing tutorials for teaching robotics, along with addressing the primary challenges faced by students at the National Engineering School of Carthage. The study was conducted with students enrolled in the "Automation, Robotics and Information Processing" master's program and could potentially be extended to other higher education institutions in Tunisia. The core of this pedagogical approach involves specifying the components of various tutorials to be made accessible to students using a systemic OOPP (oriented objectives project planning) method. This instructional method, fostering student accountability for their learning, has emerged as a cornerstone in the evolution of engineering education.

Key-Words: - Tutorials, robotics, systemics, OOPP method, control, planning.

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1 Introduction

Today, tutorial design is seen as the creative search for a solution to a problem. It must follow certain predefined and essential stages, which are, [1]:

- The choice of subject and programming language, which forms the starting point.
- Definition of the tutorial's operational objectives.
- Planning the tutorial.
- Programming and testing the tutorial.

The specification of a real-time system involves taking into account two essential characteristics: the temporal evolution of the system's components and the interaction between the system and its environment, [2]. The complexity of the relationships between a system and its environment is particularly true in the field of real-time process control, [3].

Techniques for specifying real-time systems include, [4]:

- Analysis methods to systematize and channel the various perceptions of requirements (SA, SADT, SA-RT, OOPP, etc.);
- Specification languages with well-defined syntax and semantics (Petri nets, Grafcet, etc.);
- Simulation languages used to implement modeling tools (Arena, SIMAN, SLAM, CADENCE, etc.).

This paper aims to show the interest of software for learning robotics.

2 Presentation of the Robotics

Robotics is the branch of artificial intelligence concerned with the study of automatic systems capable of direct interaction with the physical world.

Figure 1 shows how the robot works.

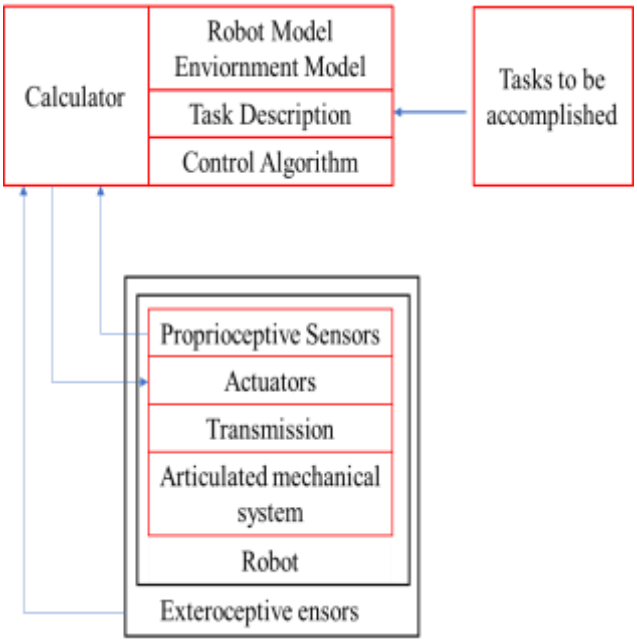

Fig. 1: Robot operation

There are two types of robots, [5]:

- Robot manipulators designed to perform a specific task are difficult to find on the market unless they have been specially designed or programmed. The majority of existing robots are called upon to question their sites and respond to the requirements of their users, [6].
- The mobile robot is of interest in the industrial field and even in everyday life, as it can be used to carry out tasks in hostile environments, managerial tasks, as a means of transport for the handicapped, common means of transport, etc. [7].

To identify the components of a robot, we have presented the following list, [8]:

- Mechanical aspect: this is the robot's skeleton, made up of five parts: chassis, structure, locomotion (wheels and legs), motor, and torque.
- Electronics: being a highly sensitive part of the robot, it must be protected. All connections between boards, sensors, motors, and power supply are sensitive points. One idea is to group as many components as possible on a single board or to group as many functions as possible on a single component.
- Power supply: this consists in defining the autonomy skipped for normal operation, and also in determining the capacity of several independent sources. The power supply is made up of the control system, batteries, chargers, and safety devices.
- Actuators: the term "actuator" covers everything that transforms electronic energy into mechanical energy. Motors and relays are considered classic actuators.
- Transistors: the main component of a motor interface is the transistor.
- Integrated circuits: these are very practical components. They incorporate everything you need to build an H-bridge. The control part is directly compatible with a microprocessor.
- Chopper: uses the principle of pulse-width modulation applied to the motor. Speed control by pulse-width modulation is much better and more efficient at low speeds.
- DC motors: these are usually combined with geared motors that reduce the motor shaft speed to reasonable values for the robot. Speed can be controlled by varying the voltage or using PWM control. The duty cycle of the signal will change the motor's torque and therefore its speed.
- Stepper motors: when used for traction, they enable precise estimation of the robot's position by counting the number of pulses sent to each motor. To take the strain off the CPU, these motors are often combined with motor control boards to generate signals and create movements through simple commands.
- Servomotors: found in many small robots. They are used in the world of model-making to perform small circular movements.
- Control unit: this is physically materialized by the microcontroller, which has its internal program to carry out the task for which it has been designed. This mode of operation is particularly well-suited to "embedded" applications, where the human operator cannot intervene directly, and where the machine's desired behavior is defined in advance.

3 Tutorial Specification

Among the stages of building a robotics tutorial is the planning stage, [9]. This stage consists of defining the various activities involved in the project, [10]. The objectives to be achieved must be set and identified, [11].

3.1 Presentation of the OOPP Method

OOPP is a global systemic modeling tool (Figure 2), [12] for analyzing a complex situation by breaking it down into a hierarchy and reducing it to elementary situations, leading to elementary operational planning, [13]. This method, widely used in the planning of complex projects, involves various operators and partners, [14].

The two decisive stages in the development of the modeling strategy are, [15]:

- The project Planning Scheme, which consists on the one hand of establishing an overall diagnosis of the situation by drawing up a Problem Tree using causal logic, and on the other hand inverting this tree to form an Objective Tree based on a "Means-End" logic, [16].
- The Activity Planning Scheme, leading to a hierarchical analysis of the results to be achieved, and the identification of the various implementation parameters (person

in charge, resources, timing, location, implementation indicators), [17].

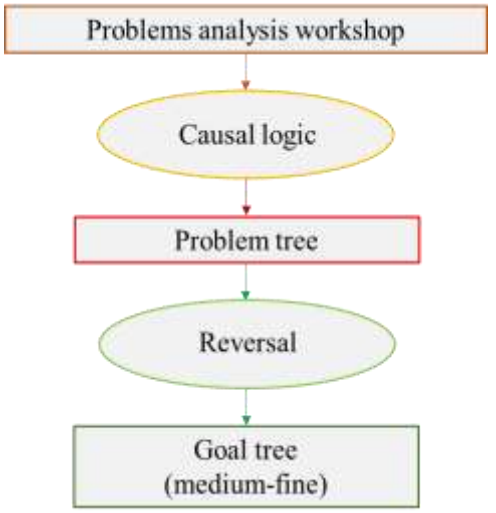

Fig. 2: OOPP model

3.2 Results of the OOPP Analysis

The specific objectives to achieve the overall objective (Figure 3) "Robotics tutorial developed" are:

- project presentation and planning (OS1);
- composition of the tutorial (OS2);
- tutorial programming (OS3);
- tutorial testing and maintenance (OS4).

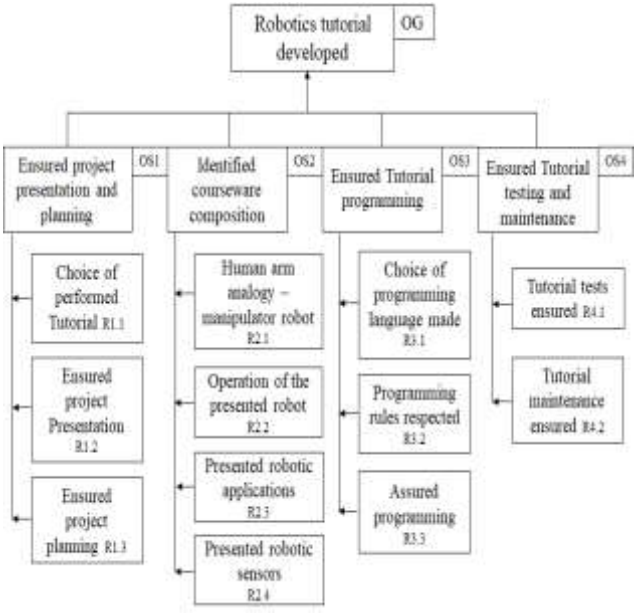

Fig. 3: Objective tree for specifying a robotics tutorial

Table 1 presents the OOPP analysis for specific objective OS3.

Table 1. OOPP analysis

N°	Code	Designation
1	OS3	Tutorial programming provided
2	R3.1	Choice of programming language made
3	Ri3.1.1	Choice of language according to system characteristics
4	Ri3.1.2	Choice according to execution speed
5	Ri3.1.3	Choice according to the quantity of code produced
6	Ri3.1.4	Choice according to team competence assured
7	Ri3.1.5	Choice based on the availability of development utilities assured
8	R3.2	Programming rules respected
9	R3.3	Ensure programming
10	Ri3.3.1	Visual Basic programming project created
11	Ri3.3.2	Use of sheets and controls ensured
12	A3.3.2.1	Modify properties
13	A3.3.2.2	Create program code
14	Ri3.3.3	Use of menus and images assured
15	Ri3.3.4	Use of custom types and structures assured

4 Conclusion

In this paper, we presented a methodology for developing a robotics tutorial based on the use of the systemic OOPP method.

This experience is currently being developed to be able to use the most advanced tools and techniques in designing tutorials.

References:

[1] C. R. Judy, Tseng, L. Wei, Innovative Voice-Activated Robots for Computational Thinking Education: Design and Development, *WSEAS Transactions on Advances in Engineering Education,* Vol. 20, pp. 52-59, 2023, https://doi.org/10.37394/232010.2023.20.8.

[2] D. Kato, K. Yoshitsugu, T. Hirogaki, E. Aoyama, and K. Takahashi, "Predicting positioning error and finding features for large industrial robots based on deep learning," *Int. J. Autom. Technol.*, vol. 15, no. 2, pp. 206–214, 2021, doi: 10.20965/IJAT.2021.

[3] F. G. Maiztegui, Design and Evaluation of an E-Learning Artefact for the Implementation of SAP S/4HANA®. *Springer Gabler,* 2023.

[4] L. Mbuagbaw, D. O. Lawson, L. Puljak, D. B. Allison and L. Thabane, A tutorial on methodological studies: the what, when, how and why. *BMC Medical Research Methodology*, vol. 20, pp.1-12, 2020.

[5] S. A. Bortoff, "Object-Oriented Modeling and Control of Delta Robots," *2018 IEEE Conf. Control Technol. Appl. CCTA 2018*, no. August 2018, pp. 251–258, doi: 10.1109/CCTA.2018.8511395.

[6] E. Emad, O. Alaa, M. Hossam, M. Ashraf, M. A. Shamseldin, Design and Implementation of a Low-Cost Microcontroller-Based an Industrial Delta Robot, *WSEAS Transactions on Computers*, Vol. 20, pp. 289-300, 2021, https://doi.org/10.37394/23205.2021.20.32.

[7] J. Tohka, J. M. Van Gils, Evaluation of machine learning algorithms for health and wellness applications: A tutorial. *Computers in Biology and Medicine*, *132*, p.104324, 2020.

[8] S. Makita, T. Sasaki, and T. Urakawa, "Offline direct teaching for a robotic manipulator in the computational space," *Int. J. Autom. Technol.*, vol. 15, no. 2, pp. 197–205, 2021, doi: 10.20965/IJAT. 2021.P0197.

[9] R. Absi, M. Lavarde, L. Jeannin, Towards more efficiency in tutorials: Active teaching with modular classroom furniture and movie-making project, *IEEE Global Engineering Education Conference (EDUCON)*, 2018, pp.774-778.

[10] G. Kohli, A. Dandriyal, P. Goyal, Enhancing education for IT literacy using spoken tutorials, *IEEE International Conference on MOOC, Innovation and Technology in Education (MITE)*, 2014, pp. 366-371.

[11] S. Alter, D. Bork, Systems Analysis and Design Toolkit Based on Work System Theory and Its Extensions, *Journal of Database Management,* Vol. 31, Issue 3, July-September 2020.

[12] N. A. Abd Samad, Z. Embong and M. A. M. Nor, Development of Telegram Bot in Supporting the Learning Process of Object-Oriented Programming. In *LIS International Conference*, Vol. 8, No. September, pp. 134-144, 2022.

[13] Z. Lin, Y. F. Wu, S. V. Peri, W. Sun, G. Singh, F. Deng, J. Jiang and S. Ahn, Space: Unsupervised object-oriented scene representation via spatial attention and decomposition. *arXiv preprint arXiv:2001.02407* , 2020.

[14] J. Han, J. Ding, J. Li and G.S. Xia, Align deep features for oriented object detection. *IEEE Transactions on Geoscience and Remote Sensing*, vol. 60, 1-11, 2021.

[15] J. El Khaldi, L. Bousslimi, A. Balti, M.N. Lakhoua, Study and analysis of the methods of the enterprise modelling, *Design Engineering*, 2022, Issue 1, pp: 2945-2948.

[16] K. Steverson, H. Chung, K. Zimmermann, J. Louie and P. Glimcher, Sensitivity of reaction time to the magnitude of rewards reveals the cost-structure of time. *Scientific Reports*, vol.9(1), 1–14, (2019).

[17] A. Hallioui, B. Herrou, System Analysis: A Literature Review, *Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management Detroit*, Michigan, USA, August 10-14, 2020.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

- J. El Khaldi, H. Wertani prepared, created and presented the published work. J. Ben Salem, formulated general aims and objectives of the research.
- L. Bousslimi, formulated general aims and objectives of the research
- J. Ben Salem, prepared, created, and published the work, in particular the writing of the initial draft.
- M. N. Lakhoua, has supervisory and leadership responsibility for the planning and execution of research activities.

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Conflict of Interest

The authors have no conflicts of interest to declare.