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(Re)CreativeRobot: Popularizing Workshop to Promote Control and Mobile Robotics for Kids

Cristina Stoica, Sylvain Bertrand, Aarsh Thakker, Thomas Chevet,
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Abstract—This paper focuses on the Workshop “(Re)Creative Mobile Robotics for Kids – (Re)CreativeRobot” for popularizing Control and Mobile Robotics for children. Inspired from the “Girls in Control” workshop, this education activity allows children to individually implement basic Control algorithms on mobile robots via Scratch programming. Its first occurrence was held during the French science festival “Fête de la Science” 2022 edition. A second occurrence was held in a primary school in the Paris region, allowing small groups of kids to collaboratively develop Scratch algorithms for mobile robots. This paper shows some insights and perspectives of this perennial interactive Control Education activity.

Index Terms—Automatic Control Education and Training, Popularizing science to promote Control and Mobile Robotics, Autonomous vehicles

I. INTRODUCTION

The online workshop “Girls in Control” ([1], [2]) revealed the necessity of motivating and inspiring programs for kids all around the world. With the increasing development of technology, science becomes more than ever within everyone’s reach. More and more research laboratories and universities open their doors to broad public during Open Days events ([3]). However, research materials are often expensive and not appropriate for children use. In order to allow kids having a realistic scientific experience, there is need to equip the academic and research labs with durable equipment with user-friendly design, while allowing recreative, funny, modern and scientifically sound pedagogic activities.

The Automatic Control community (see [4], [5]) understands the importance of multiplying the popularizing science activities and devices in order to increase the social impact of Automation and Control, and, more generally, of Science, Technology, Engineering, and Mathematics (STEM) [6]. Promoting early math learning integrating educational

games has broad advantages for the future of the scientific community [7]. Robotics is a scientific field facilitating the perception of engineering (Control, Mechanics, Mechatronics, Informatics, Artificial Intelligence, etc.) with the advantage of creating a symbiosis between theory and practice. There exist numerous pedagogic devices and works on Robotics applications explained for the general public, more particularly for children. These include new robotic technologies, case studies on robots used for children education [8], curricula innovations for teaching programming fundamentals, Robotics and Control to young students [3], Control Engineering for kids via interactive games [9], etc. Elementary programming for kids within blocks-oriented languages (e.g. Scratch [10], [11], Roboblockly [12], Blockly [13], mBlock [14]) is a remarkable progress in popularizing engineering education. There are more and more robots interacting with children (e.g. ChildBot [15]) and this could increase even more the kids’ interest for Robotics and related scientific fields.

After the Covid19 pandemic, moving from online educational activities to on-site teaching activities was greatly welcome by learners all around the world. In this context, the goal of this paper is to propose a new on-site perennial interactive workshop for children “(Re)CreativeRobot” allowing them to develop practical skills on mobile robots’ and drones’ automatic control, motivating them to pursue later on their curriculum in engineering and, thus, contributing to early spread Control Education. A first version of this workshop was held at the national event “Fête de la Science”. This is a large-scale science festival, created 31 years ago, and organized yearly by the *French Ministry of Higher Education, Research and Innovation* to promote and popularize science in France [16]. This successful festival offers thousands of free events open to everyone, including kids, young people, etc. The first version of the workshop proposed several basic exercises in Scratch allowing each kid to control one mobile robot, i.e. *single robot control by one kid* (Phase W1 in Fig. 1). In the next stage, the workshop was adapted in order to allow one small group of children to implement elementary exercises in Scratch (e.g. tracking a specific trajectory or a specific robot) on the robot allocated to their group, i.e. *single robot control by several children* (Phase W2.a in Fig. 1). Two sessions were organized for the 9-years old pupils (who already have basic notions of Scratch) of the primary school Roger Ferdinand, in Palaiseau, allowing them to work in teams of two or three kids on the same robot. One contribution of this work is to propose exercises that allow to regroup the results of all the

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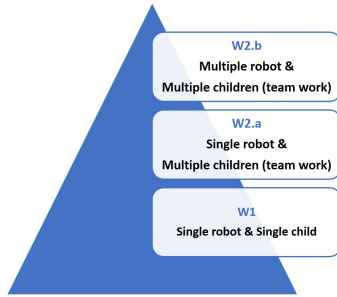


Fig. 1. (Re)CreativeRobot Workshop phases, with increased complexity from level W1 to level W2.b

groups in order to address basic multi-agent systems control problems involving, for instance, leader-follower formations, i.e. *multiple robot control by all the groups of children* (Phase W2.b in Fig. 1). Another original aspect of this work is to involve undergraduate students from the projects cluster “Pedagogical Innovation and EdTech” of CentraleSupélec¹ together with industrial and academic researchers in Control. A video describing the main steps of this work is available at www.youtube.com/watch?v=3UXQVUPvKN4.

The remaining part of this paper is organized as follows. Section II focuses on the activity description and pedagogical aspects. The hardware setup is detailed in Section III, while some examples developed within the Scratch environment are provided in Section IV. The next section focuses on the workshop perception and the futures steps. Conclusion remarks are drawn in Section VI.

II. WORKSHOP OUTLINE

This section presents the target audience and the main educative activities proposed during the workshop.

A. Target audience

The proposed learning activities are designed for children from any social environment, providing them access to high-standard educative material and interactive pedagogical activities, opportunities to interact with engineering students and academic participants to answer their questions, to explain the benefits and impact of engineering and science for humanity, to explain the advantages of an engineering career, to advise them individually, etc.

The workshop targets children from 8 to 14 years old who know basic Scratch notions. Several experimentation sessions (approx. 15-20 children per session, 3 or 4 children sharing one robot) are planned at several events, e.g. “Fête de la Science”, Open Days at CentraleSupélec and Univ. Paris-Saclay, etc.

B. Activity description

Inspired by the “Girls in Control” online event, the “(Re)CreativeRobot” is a hands-on perennial workshop based on active pedagogy learning methods. During this educational

¹CentraleSupélec is one of the most distinguished French graduate engineering schools, called “Grandes Ecoles”, with a selective entrance exam.

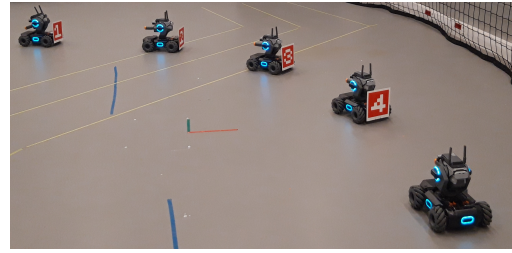


Fig. 2. Scratch-based leader-follower approach with 5 robots

activity, children learn how to control mobile robots using Scratch (Python programming is expected in a future edition dedicated to teenagers).

After assembling the robots, the first phase of this work focused on the development of the materials necessary for the workshop: scientific content, algorithms, interactive pedagogical activities, etc. The scientific content of the workshop goes from Programming (in Scratch) to Robotics and Control Engineering, with an opening to Artificial Intelligence and Computer Vision.

The “Fête de la Science” event focused on a *Single robot & single child* approach (W1 in Fig. 1). Thus, basic fill-in-the-gaps programming exercises were proposed. Indeed, each child was able to test target identification and elementary path following approaches while avoiding obstacles.

During the “Fête de la Science” event, while the children were programming, their parents were discussing with some of the team members. In addition, some contacts with regional primary and secondary schools were established thanks to these interactions. Following these discussions, we organized a second occurrence of the workshop for one class of 27 pupils of 9-years old of the primary school Roger Ferdinand, in Palaiseau. Two sessions were organized: a first session for 15 kids and a second one for 12 kids, working in small groups of two or three kids with one robot/group. There were four main phases of the workshop: 1. an introduction for all the kids participating to the session, with interactive questions and a quick demonstration on one robot; 2. work in small groups (e.g. discovering the robot facilities, programming simple trajectory tracking algorithms); 3. a short playing session with the robots allowing interactions between groups; 4. concluding remarks regrouping all the kids.

The workshop held in the primary school in Palaiseau focused on a *Single robot & multiple children* approach (W2.a in Fig. 1) allowing children to work in a small group on the same robot. The kids implemented basic trajectory generation and trajectory tracking algorithms in Scratch, using simplified fill-in-the-gaps programs.

The idea of the *Multiple robot & multiple children* approach (W2.b in Fig. 1) is to teach them the advantages of collaborative work and to make the link with basic notions of Multi-Agent Systems. Two examples are illustrated in this paper: 1. Implementing basic leader-follower/platooning concepts with 5 robots (Fig. 2); 2. Drawing the IFAC logo via light painting



Fig. 3. IFAC logo via light painting with one mobile robot

with one or several robots (Fig. 3). This kind of approaches can be interesting to make the link between Arts and Engineering and open new perspectives to the attendees of the workshop.

The video <https://youtu.be/3UXQVUPvKN4> describes the main steps of this work: 1. robots assembling; 2. Path following experiments during the “Fête de la Science” 2022 event; 3. Scratch-based leader-follower approach using 5 mobile robots (Fig. 2); 4. Practice of the path following to plot the IFAC logo (Fig. 3) via light painting.

III. HARDWARE SETUP

This section offers some details on this educational activity implementation. Five ground mobile robots DJI RoboMaster S1 are available in our lab, allowing five groups of children to work at the same time on such a robot within the flight arena of CentraleSupélec. This smart educational robot with an omnidirectional motion chassis is able to move forward, backward, sideward, skew and/or rotate, to detect and recognize lines, vision markers, persons, hand movements, applause, other robots DJI RoboMaster S1, and to make specific moves and sounds, ensuring hands-on learning in a friendly atmosphere. Besides several programming notions in Scratch, basic notions of trajectory generation and trajectory tracking are taught, based on funny games. The DJI RoboMaster S1 robot is programmable both in Scratch and Python, and can thus be used for teaching activities for kids, teenagers, students, etc.

In the RoboMaster application, there are three available modes for the RoboMaster S1:

- *Solo mode*, allowing a single user to control the robot manually;
- *Battle mode*, allowing several users to play a game with several robots (multi-player games with manual control);
- *Lab mode*, allowing to code in Scratch or Python. Several videos and starting codes are provided within the RoboAcademy.

Motion control is available for this robot, e.g. forward, backward or sideward control of the chassis, yaw and pitch control of the gimbal, yaw control of the chassis, speed control of the chassis motion.

The following hardware connection steps are necessary for the experiment setup, as detailed in Fig. 4:

- 1) setup a router² and keep the router password handy;

²A dedicated router is advised for security reasons.

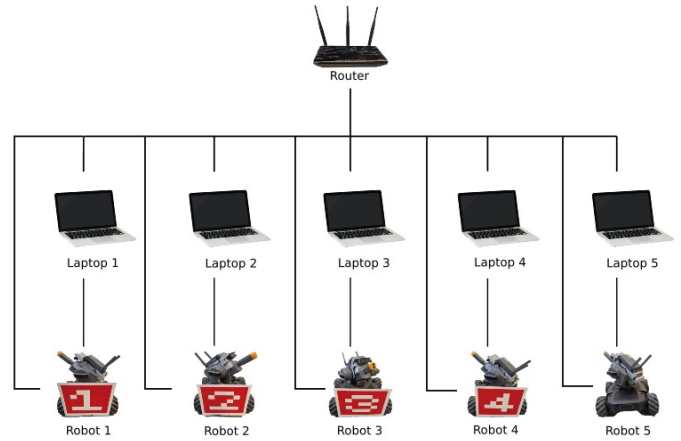


Fig. 4. Router connection

- 2) connect each laptop i with the router (with $i \in \{1, 2, \dots, 5\}$ in our case);
- 3) open the RoboMaster application on each laptop;
- 4) turn on each robot and put it in the *router mode*;
- 5) connect each robot to the router using the RoboMaster application.

The next steps³ are necessary when running the code:

- 1) go to the *Lab mode* in the RoboMaster application;
- 2) open the code;
- 3) put the robots in the convenient places in the arena;
- 4) play the script in Laptops 2 to 5 (in order to control the robots 2 to 5);
- 5) maneuver the robot 1 within the *Solo mode* using the keyboard or code an automatic trajectory tracking for the robot 1.

IV. EXAMPLES OF SCRATCH IMPLEMENTATION

A basic Scratch example illustrating the capability of the DJI RoboMaster S1 to recognize gestures, to control the chassis rotation and translation speed is provided in Fig. 5.

An example of a Scratch program to obtain the IFAC logo via light painting with one robot is provided in Fig. 6. There is one main part (i.e. the *Start* block) and one function for each letter (i.e. *I*, *F*, *A*, *C* letters) and the IFAC logo. This modular code gives the possibility to each child to make the robot following a trajectory identical to one letter. Then, it is possible to put together the work of several groups in order to write a given word. Wordle-like exercises can be envisaged within this context allowing children to develop multiple skills. Artistic shapes can be obtained with different trajectories and LED colours used by several groups of children. This can be an additional motivation for kids.

V. WORKSHOP IMPACT AND FUTURE STEPS

This section offers some elements on the perception of this workshop, together with some future directions.

³The reader will notice that steps (3) and (4) are specific for the leader-follower application with the first robot manually driven.

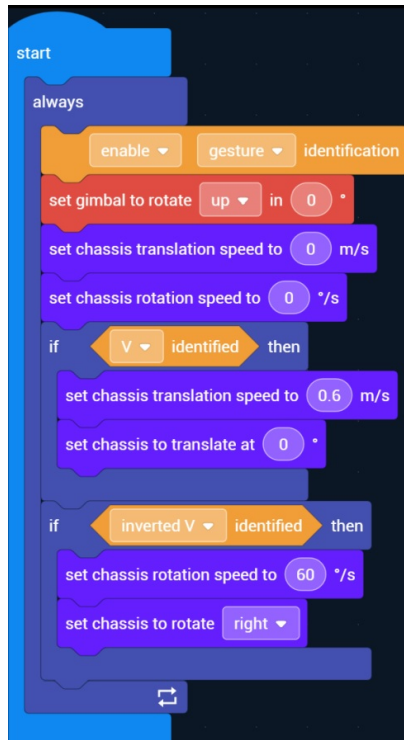


Fig. 5. Example of basic Scratch code for the robot

A. Some feedback

Learners' feedback. During the "Fête de la Science" occurrence, both the kids and their parents were happy with the proposed activities. In addition, some of the parents put us in contact with the schools of their kids. Such an action allowed us to have a second occurrence of the workshop in a primary school in our region. The primary school teachers were happy to establish this contact and we felt very welcome in their institutions. The kids were absolutely excited about working on the robots, they thanked us and asked when we will come back. This is an encouraging feedback which motivates us to continue with this direction.

Teachers' feedback. An important time is allocated to identify the appropriate mobile robots for a given teaching activity, to get the funding, to purchase the mobile robots, to assemble them, to understand the operation mode and to develop pedagogical activities. Some time can be saved by using the same robots and the developed materials shared within open access (see https://github.com/L2S-lab/ReCreative_Robot_ICSTCC2023).

An interesting point in working with children was the particular attention that is needed for each child in order to facilitate their interaction with the robots. Thus, we prefer to have one instructor per each group of two or three kids, in order to allow each kid to interact with the robots. Thus, we were 5 or 6 instructors for a group of 12 to 15 kids, in a large space. We advice to delimit the arena by boxes or gym carpets, to avoid collisions of the robots with walls, tables,

chairs, etc. We observed that if one group of kids proposes a new experiment on the robots, the other kids encourage themselves to success in their experimentations. Allowing the kids to work in open-space and to see the results of the other groups motivated them and allowed them to improve their creativity.

We mainly run the workshop in the flight arena of Centrale-Supélec, which was very convenient because all the material was already there. When putting in place the workshop in a different location, an indoor sports room (equipped with enough power supplies) with a few additional tables and chairs is a perfect place. We recommend to bring the entire material (one robot and one laptop with additional keyboard and mouse per group, together with the WiFi router).

From the pedagogical point of view, we advise to structure the workshop as follows⁴, for a total duration of 90 minutes:

- Starting with an icebreaker group activity increases the interactions with the classroom.
- Then, presenting the robots facilities and one short demo makes the kids curious about it.
- When working in small groups (Phase W2.a Single robot & Multiple children in Fig. 1), there is a first time dedicated to get started (discover the robot, understand the main functions, etc.). Then, the kids start naturally to program different tasks for the robot (one kid at a time, implementing the best idea of their group). The tasks (e.g. marker tracking, gesture recognition implemented using *for loops* which are part of the kids' curriculum) will be suggested by the instructors and they could be adapted to each group.
- An interesting exercise is to propose activities to each group that can be put together (Phase W2.b Multiple robot & Multiple children in Fig. 1) in order to create a more complicated experimentation. For instance, each group of kids can program a robot to follow a specific marker. Then, all the results can be combined, while sticking one marker to each robot in order to create a platoon-formation (see Fig. 2). The first robot of the platoon-system can be programmed to follow one kid walking in the room, which is very well appreciated by the kids.
- At the end⁵ of the workshop, we suggest to dedicate a few minutes for playing with the robots.
- Concluding remarks and announcing the next event with the robots offers them a good perspective.

B. Further developments and activities

The project "(Re)CreativeRobot" allowed us to purchase nine drones DJI RoboMaster TT, which can be programmed in Scratch or Python. Equipped with environmental perception, these drones are dedicated to lowering the threshold

⁴Single robot & Single child (see Phase W1 in Fig. 1) are advised during events with a few kids who want to deepen their understanding of certain concepts. A duration of 30 minutes per W1 session is advised.

⁵Otherwise, it is complicated to get the kids focused on programming rather than playing.

for Robotics and Artificial Intelligence learning. Advanced trajectory generation and tracking while avoiding collisions, together with artistic consensus on a swarm of drones will be proposed for youths.

Therefore, a second workshop involving drones will be proposed for the 2023 edition of the “Fête de la Science” science festival. The main goal is to develop educative devices in order to allow children to develop basic programming skills for drones and swarms of drones. With a children friendly design, the drone DJI RoboMaster TT offers the requirements for this workshop, allowing simple developments for a single drone and also for a swarm. The new indoor flight arena (10m x 5m x 3m) of CentraleSupélec will be used for the experiments on drones. In addition, the students of the projects cluster “Pedagogical Innovation and EdTech” of CentraleSupélec are already involved in designing this new workshop.

An advanced session, allowing teenagers and students to program both the mobile robots and drones in Python will be developed in the future.

Another perspective of this work focuses on the gamification of Control courses within engineering curricula, e.g. escape games-type (see [17]) using mobile robots, which will increase the visibility of Control among students. Future developments consist in designing an advanced level workshop on classic control techniques (e.g. PID, feedforward control), together with basic Artificial Intelligence notions, for undergraduate students, based on Python programming.

VI. CONCLUSION

This paper proposed an overview of the (Re)CreativeRobot workshop allowing children to familiarize with basic Control concepts via experimentation on mobile robots using Scratch. Starting with a classic approach where each child programs one mobile robot, the workshop was adapted in order to: 1. allow one group of children working in team to implement a basic program on a single robot; 2. regroup the developments of all the groups during the classroom session and implement multi-agent system control techniques on several robots. Part of the developed pedagogical material is available on https://github.com/L2S-lab/ReCreative_Robot_ICSTCC2023 and will be added on the Educational Resource Compendium [18]. This perennial “(Re)CreativeRobot” workshop is indented to strongly contribute to the visibility of Control Engineering and Robotics to the younger generations, while making Control and Mobile Robotics accessible and motivating children to pursue later on their curriculum in engineering, while promoting equal opportunity, inclusion and diversity.

Future developments focus on developing a similar workshop using drones. A quantitative analysis of the learners’ feedback is an important part to be completed.

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```

start
  turn off all LED
  wait 5 s
  logo
  set chassis to translate at -180 * for 0.2 m
  set chassis to translate at -90 * for 1 m
  i
  set chassis to translate at -90 * for 0.5 m
  f
  set chassis to translate at -90 * for 0.5 m
  a
  set chassis to translate at -90 * for 1 m
  c
  set chassis to translate at -90 * for 1.1 m
  turn off all LED
  wait 5 s

function logo
  turn off all LED
  set chassis translation speed to 0.5 m/s
  set chassis front LED color to and effect to solid
  set chassis to translate at -90 * for 0.7 m
  set chassis to translate at 90 * for 1.4 m
  set chassis to translate at -90 * for 0.7 m
  set yaw to -90
  repeat 180
    set chassis to translate yaw * at 0.5 m/s
    wait 0.03 s
    increase yaw by 2
    if yaw > 180 then
      set yaw to -180
    if yaw <= 130 and yaw >= 50 then
      turn off all LED
    else
      set chassis front LED color to and effect to solid
  turn off all LED

function i
  set chassis front LED color to and effect to solid
  set chassis to translate at 0 * for 1.2 m
  set chassis to translate at 180 * for 1.2 m
  turn off all LED

function a
  set chassis front LED color to and effect to solid
  set chassis to translate at 30 * for 1.2 m
  wait 0.5 s
  turn off all LED
  set chassis to translate at -150 * for 1.2 m
  wait 0.5 s
  set chassis front LED color to and effect to solid
  set chassis to translate at -30 * for 1.2 m
  turn off all LED
  wait 0.5 s
  set chassis to translate at 150 * for 1.2 m
  wait 0.5 s
  turn off all LED
  set chassis to translate at 0 * for 0.4 m
  set chassis front LED color to and effect to solid
  set chassis to translate at -90 * for 0.3 m
  set chassis to translate at 90 * for 0.5 m
  set chassis to translate at -90 * for 0.3 m
  turn off all LED
  set chassis to translate at -180 * for 0.4 m

function f
  set chassis front LED color to and effect to solid
  set chassis to translate at -90 * for 0.7 m
  set chassis to translate at 90 * for 0.7 m
  set chassis to translate at 0 * for 1.2 m
  set chassis to translate at -180 * for 0.8 m
  set chassis to translate at -90 * for 0.4 m
  set chassis to translate at 90 * for 0.4 m
  set chassis to translate at -180 * for 0.4 m
  turn off all LED

function c
  turn off all LED
  set chassis to translate at 0 * for 0.2 m
  set chassis front LED color to and effect to solid
  set yaw to -135
  repeat 180
    set chassis to translate yaw * at 0.5 m/s
    wait 0.03 s
    increase yaw by 2
    if yaw > 180 then
      set yaw to -180
    if yaw <= 70 and yaw >= -70 then
      turn off all LED
    else
      set chassis front LED color to and effect to solid
  turn off all LED
  
```

Fig. 6. Example of a modular Scratch code using functions to obtain the IFAC logo via light painting with one robot