An AI Robotics & Ethics Summer Camp for High School Students

William Slaton[1], Lin Zhang[1], and Jesse Butler[2]

[1]Department of Physics, Astronomy, and Engineering, The University of Central Arkansas, Conway AR 72034
[2]Department of Philosophy and Religion, The University of Central Arkansas, Conway AR 72034

Abstract

Self driving vehicles and autonomous robots are no longer the stuff of science fiction and constitute areas of engineering and ethics that are important now and into the future. With this need in mind we created an artificial intelligence robotics and ethics summer camp for high school students that has them build, program, and train an autonomous robot to compete on a test track. The camp attendees also engage with the ethical implications and considerations this technology embodies. The familiar ethical dilemma of the Trolley Car Problem is now something autonomous vehicles will have to make split second decisions about as this technology becomes more commonplace. This camp educates the engineers of the future about machine learning and autonomous vehicles while also engaging their minds to consider the forward-looking ethical issues inherent with this technology.

Keywords

Artificial Intelligence, Machine Learning, Robotics, Philosophy, Ethics

Introduction

In the summer of 2024 we delivered a week-long day camp at the University of Central Arkansas that provided students with hands-on learning opportunities in the fields of artificial intelligence, machine learning, and robotics with an emphasis on the moral and ethical dimension of this technology. During the week student teams learned programming and hardware skills to build and test machine learning algorithms to train and autonomously test-drive a robot car. The week culminated in a competition where the teams showcase what they have learned for family and friends. Our student learning objectives for the camp were the following:

1. An ability to create programs of level-appropriate complexity to design, build and test an autonomous robot by applying principles of artificial intelligence and machine learning.
2. An ability to recognize ethical and professional responsibilities in the engineering of autonomous agents and make informed judgements weighing their impacts on global, economic, environmental, and societal contexts.

These learning outcomes formed the basis of the pre/post assessment of the camp which consisted of a multiple choice quiz as well as an essay. The quiz and essay rubric appear in the appendix.

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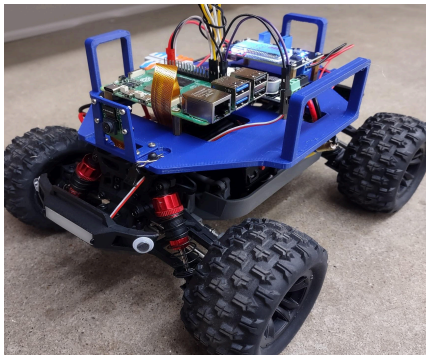
Methods

1. AI and Robotics Education Platform - BearCart

BearCart [1] is an open-sourced project (See picture to the right) which implements a minimal self-driving technology using AI. This project is designed to provide educational resources to high school students with a little computer science background. However, any person who is interested in robotics and AI can follow the paired instructions and documents to customize an RC car and teach it to drive itself through the behavioral cloning approach [2]. The students will gain understanding on a handful of topics, such as how a robot perceives and actuates, how a robot learns from a (human) expert, how a deep learning model serves decision making, how a neural network model evolves. The students will also practice their skills such as hardware manipulation, Python programming and Linux usage.



The establishment of such an education platform is mainly attributed to the development of the curriculum that introduces AI to the undergraduate students majoring in engineering physics at University of Central Arkansas [3]. Strongly inspired by the open-sourced DonkeyCar [4] project, three classes of students (Fall, 2021 - Spring, 2024) developed the backbone of the BearCart project. Now, we are able to summarize all the resources from the college classroom and offer this educational project to the high school students and people in a wider range.

a. Hardware

The physical base of the robot is an off the shelf 1/16 scale RC car. To enable autonomous decision making, a Raspberry Pi 5 single board computer (SBC) is required on board. The robot relies on a Raspberry Pi Camera as its only source of perception. A brushed DC motor serves as the engine to propel the robot. We employ an H-bridge configured motor driver circuit to regulate the engine velocity. A servo motor is in charge of steering the front wheels of the robot. We use the Raspberry Pi 5 SBC to output pulse width modulation (PWM) signals to control the velocity of the engine and the angle of the steering servo. Two step-down converters are also included onboard to provide regulated power for the SBC and the steering servo. To collect humans' driving data, as well as provide an emergency stop function, a wireless controller is required. Interested readers can access the full part list, mechanical assembly guide, and details of the electrical components, wiring and other information at the BearCart Github repository [1].

b. Software

The software of the BearCart project is mainly composed with three Python scripts and a configuration file as shown in Fig. 1. Students with less computer science experience will be able to utilize the software at the user level. A user can adjust the drivetrain configurations (speed limit, steering range, controller key binding, etc.) in a text file formatted in JavaScript Object Notation (JSON). Students with stronger computer science backgrounds or with more curiosity are welcome to tweak not only the drivetrain but also the AI learning process at the developer level. A developer is free to modify the Python scripts to manipulate the human driving dataset and the neural network powered autopilot model with his/her own flavors. Any interested user or developer can follow the software usage instructions at the BearCart Github repository [1] to train and test out AI driven autopilot models.

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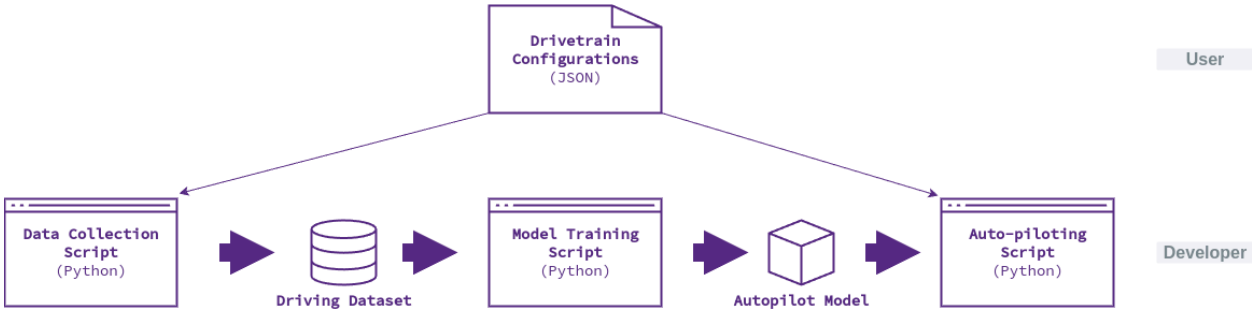

Fig. 1 BearCart software layout

2. Ethical Reasoning and Responsibilities

To develop ethical reflections regarding the responsibilities of creating and using self-driving cars, as well as to challenge the students to generate their own informed judgements regarding the ethical use of robotics and artificial intelligence more generally, we designed an interactive and student-driven curriculum that began and ended with the same ethical reasoning assessment essay prompt (see appendix).

On the morning of the first day, students completed the pre-assessment essays individually. That afternoon, after the students had developed teams and began their car projects, we put them into groups to share and compare their individual essay responses, with the goal of reasoning together to reach consensus agreement on their answers, if possible. Afterwards, each group presented their shared answers and Dr. Butler facilitated a discussion between them, building on the multiple pros and cons generated by the students' own reflections to map out the economic, environmental, and societal implications of developing self-driving cars for use on public roads.

During subsequent days, intermixed with car project activities, the students were introduced to further basic ethical issues and viewpoints regarding self-driving cars, robotics, and artificial intelligence, such as the "Trolley Problem" thought experiment, Isaac Asimov's Laws of Robotics, and the general question of to what extent automated machines might be programmed to make ethical decisions themselves [5]. Students were again asked to share and compare their views on the issues amongst themselves in groups, and then Dr. Butler facilitated discussion and debate between them, guiding them to enrich and expand their understanding of the significant real-world concerns that come up with the goals of developing and implementing ethical technologies. The students were also taught basic skills in constructing logical arguments to support their conclusions and engaged in a mock Ethics Bowl competition led by one of our college student facilitators (a philosophy major who is a member of a winning collegiate Ethics Bowl team at UCA) [6].

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On the final day, the students again completed the ethical reasoning essay assessment and had a general discussion reflecting on to what extent they changed their minds or not regarding the development and use of self-driving cars on public roads.

Results

The camp hosted sixteen students of which twelve completed both the pre/post camp assessments that appear in the appendix. Table 1 summarizes the data collected from these assessments. The assessment for the ethics essay is scored from 0-4pts while the multiple choice quiz contains six questions each scored 1pt each for a total of 10 total points possible. The multiple choice quiz had some questions with multiple correct answers but only fully correct responses were scored. Overall eight of the twelve (67%) showed improvement by the end of camp. These results are disappointing to the authors but highlights areas for improvement in the future.

	Pre	Pre	Pre	Post	Post	Post	Percent
Camper	Essay	Quiz	Total	Essay	Quiz	Total	Change
1	1	4	50%	2	3	50%	0%
2	1	5	60%	2	5	70%	17%
3	3	3	60%	3	4	70%	17%
4	2	2	40%	2	3	50%	25%
5	2	2	40%	2	2	40%	0%
6	3	3	60%	4	3	70%	17%
7	2	4	60%	1	3	40%	-33%
8	2	4	60%	2	5	70%	17%
9	3	4	70%	4	4	80%	14%
10	2	3	50%	2	4	60%	20%
11	2	3	50%	2	4	60%	20%
12	1	3	40%	2	2	40%	0%

Table 1. Student response data to pre/post assessment.

Summary

The project presented here represents a fun and fruitful collaboration between engineering and philosophy faculty at our university to develop a curriculum and workflow for high school students to learn about machine learning and artificial intelligence in the context of self-driving cars as well as engaging with realistic ethical issues of this technology as it exists and is likely to exist in the near future. Ample issues remain to be worked out as the sample size of students participating in the camp is small and the pre/post results are encouraging but not definitive. Future work will streamline the educational content and its delivery during the camp.

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Biographical Information

William V. Slaton received his Ph.D. in Physics from The University of Mississippi in 2001. After a two year post-doc at the Technical University of Eindhoven, The Netherlands, he joined the Physics Department at the University of Central Arkansas in 2004. In 2019 he assumed the role of Engineering Physics Coordinator in the department. His research interests include acoustics and applications of engineering physics.

Dr. Lin Zhang received his Ph.D. degree in Engineering from New Mexico State University in 2016. He is currently an assistant professor with the Department of Physics and Astronomy at University of Central Arkansas. His major research interests are deep reinforcement learning and robotics.

Dr. Jesse Butler received his Ph.D. in Philosophy from the University of Oklahoma in 2006 and joined the Department of Philosophy and Religion at the University of Central Arkansas in 2007, where he now serves as Full Professor and continues to teach courses in philosophy, ethics, and critical thinking. He is also a US Fulbright Scholar and taught courses on American philosophy at Jinan University in Guangzhou, China in 2016-17. His major research area is the philosophy of mind and his recent work focuses on the virtues of ecological self-understanding, with applications in mental health, environmental ethics, and responsible use of technology.

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Appendices

Self-Driving Car Ethical Reasoning Assessment

Pre and Post Essay Prompt:

Do you think that self-driving cars should be developed for use on public roads? Why or why not? Write two or three substantive paragraphs to explain and support your answer.

Assessment Rubric:

Score	Description
4	Demonstrates deep and nuanced understanding of the topic, with attention to multiple important ethical implications. Provides logical and convincing reasoning to fully support a clear and well-developed answer, with relevant sensitivity to possible objections / counterpoints as well.
3	Demonstrates an informed understanding of the topic and explains a well-developed answer to the question, with sufficient details given to support the answer with relevant reasoning, showing good awareness of the ethical implications of the topic overall.
2	Demonstrates a general understanding of the topic and provides a clear answer to the question, but the reasoning given is incomplete, under-developed, and/or overlooks important aspects of ethical implications of the topic.
1	Demonstrates some vague understanding of the topic and attempts to answer the question, but fails to provide clear support for the answer given and/or shows substantive lack of awareness of the ethical implications of the topic.
0	Demonstrates no understanding of the topic and fails to provide an identifiable answer to the question.

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Multiple Choice AI & Robotics Pre/Post Assessment. Accepted answers highlighted in bold.

1. What is a Raspberry Pi?
   A) Grandma's secret recipe
   B) A credit card-sized computer
   C) A popular mobile phone
   D) A brand of headphones
2. What is artificial intelligence (AI)?
   A) A type of robot designed for space exploration
   B) A branch of computer science focused on creating systems capable of performing tasks that typically require human intelligence
   C) A type of virtual reality used in gaming
   D) A technique for teleportation in science fiction
3. What is behavioral cloning in the context of artificial intelligence?
   A) Teaching robots to mimic human behavior
   B) Teaching robots to learn behaviors from other robots/agents
   C) Programming AI to play video games autonomously
   D) Using AI to create realistic animations for movies
4. What does the print() function do in Python?
   A) Pause the execution of the program
   B) Take user input from the keyboard
   C) Display output to the console
   D) Define a new function
5. Which of the following statements about self-driving cars is true? (Select all that apply)
   A) Self-driving cars rely solely on GPS for navigation.
   B) Level 5 autonomy means a car can operate without any human intervention in all conditions.
   C) Lidar sensors are commonly used in self-driving cars for environment perception.
   D) Self-driving cars are legal and widely available for consumer purchase worldwide.
   E) Neural networks and machine learning are commonly used technologies in self-driving car development.
6. Which of the following are true about neural networks? (Select all that apply)
   A) Neural networks are inspired by the structure and function of the human brain.
   B) Backpropagation is a method used to update the weights of the network.
   C) All neural networks require labeled data for training.
   D) Convolutional Neural Networks (CNNs) are commonly used for natural language processing tasks.

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