INFORMATION SYSTEMS EDUCATION JOURNAL

Volume 21, No. 1
March 2023
ISSN: 1545-679X

In this issue:

We have bundled together a number of papers on the general theme of information systems program offerings, including a look at autonomous vehicles in IS education, micro-credentials, user experience design in community projects, first-year experience courses, exam complexity, and IS2020 across the curriculum.

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Prospects of Autonomous Vehicle Learning Kits in Education Systems

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Abstract

The Autonomous Vehicles (AV) are a self-driving vehicle capable of sensing its environment and operating with minimal or no human intervention converting into a fully or partially automated vehicle. These automated vehicles have great potential to revolutionize the automotive industry and our daily lives. Thus, they are receiving a lot of attention from automotive industries, governments, suppliers, educational sectors, researchers, and many other stakeholders. According to global financial service firm UBS, the AV market could reach more than $2 trillion by 2030. These projections will become reality if enough skilled workforces are produced with a high level of broad technical competencies specifically for the automotive environment. This will also require consumer education on AVs that could bring all the comfort and excitement across all segments of the population. This brings a substantial opportunity for the educational sectors in generating the workforce required in AV sectors by enhancing the existing curricula in the areas related to AVs or developing a cross-disciplinary course or capstone project that could expose students with a technical background in computer science, computer engineering, electrical engineering, and mechatronics. Since AV has many technologies involved, it is challenging to design an appropriate curriculum and provide hands-on activities. Small-scale learning kits may be an affordable and effective solution for introductory courses on AVs or for beginners. This paper will discuss the use of those widely available small-scale learning kits, their benefits, and their challenges.

Keywords: Autonomous Vehicles, AV, Autonomous Systems, Artificial Intelligence, AI, Learning Kits, AV Education, IoT Application, IoT Development Kit, IoT Starter Kit.

1. INTRODUCTION

Automation and robotics technologies have traditionally been used by the manufacturing industries. Recent advancement of these technologies is spurting into an autonomous system that can respond to real-world conditions with minimal or no human intervention. In such an autonomous system, one can achieve a given set of goals in a changing environment—gathering information about the environment and working for an extended period without human control or intervention (Ultimate Guides, n.d.). These autonomous systems (AS) need the ability to acquire data about its environments and adapt or refine its behavior in real-time (MIT AeroAstro, 2021). AS is bringing enormous efficiencies in productivity, unmanned surveillance, unmanned navigation, and handling of harmful environments. It focuses on developing embodied intelligent systems, for example, intelligent navigation, remote monitoring, autonomous warehouse, autonomous drones, autonomous vehicles, etc. With so many potential application areas, it can have a strong economic contribution as an industrial and commercial activity and disruptive socio-economic impact across diverse market sectors worldwide (Robotics and Autonomous Systems, n.d.).

According to CIO analysts Kevin Dennean, Rolf Ganter, and Hartmut Issel,the AV industry could reach more than $2 trillion by 2030 (UBS, 2021). It will create more than 100,000 jobs in the AV industry and 30,000 jobs for engineers with computer science degrees that the US can't fill (Rayome, A. D. N., Staff, T. R., Fernandez, R., Okeke, F., Miles, B., Bohon, C., & Librescu, M., 2019). For this huge growth potential of AV sectors and workforce gap, it is required to generate a well-trained workforce equipped with the necessary skills that are required for conducting research and development projects in AV industries. This creates the opportunity for educators to effectively design and deliver related course content.

2. AV IN EDUCATION SYSTEMS

With the immense growth potential of AV sectors, many sectors including governments, transportation sectors, suppliers, traditional auto manufacturers, etc. are attracted to AV. Educational sectors and educators have an excellent opportunity to update their curricula to incorporate AVs in their educational activities. Since AV is a complex cross-disciplinary subject that has many technologies involved, it is challenging to design an appropriate education and training program. Rather, most of the existing courses focus on one or two technologies (Liu, S., Gaudiot, J.-L., & Kasahara, H., 2021). The major issue is what should be emphasized: hardware, software, programming languages, artificial intelligence, car platforms, tools, software development frameworks, computing platforms, architectures, or other topics (Bastiaan, J., Peters, D., Pimentel, J., & Zadeh, M., 2019). The most important change in education will be emphasizing the electrical/electronic systems and computer diagnostics components (Hadfield, C., 2020).

There are three major categories of AV in education activities:

a) Integrating AV topics on the Existing Curriculum for example Control Systems, Computer Vision, AI, Automation, Image Recognition, smart cities, Intelligent Transportation Systems, Machine Learning, etc.
b) Incorporating AV courses in the New Curriculum for example: Control of Autonomous Vehicles, Vehicle Dynamics, Vehicular Communication, Ethics and Legal Issues
c) Offering Project Based Course related to Autonomous Vehicles topics

3. AV LEARNING KITS/TOOLS

AV learning kits or tools consist of a set of relatively inexpensive and flexible components, including breadboards, jumper wires, development controller boards, sensors, motors, driving mats, and electric components like resistors, capacitors, and inductors. Commonly used development boards are Arduino-UNO, Raspberry Pi, Intel Galileo boards, beagle bone, Jetson Nano, etc. These kinds of kits are called do-it-yourself kits (DIY Kits) or ready-to-run (R2R) kits.

These kinds of DIY learning kits come as all-in-one packet kits along with all the required components and step-by-step instructions (Level 5 Supplies n.d.). Some kits may require additional components or a robot car which will be included in the DIY instruction sets. Most of these kits come with a smartphone app or computer software that allows easy connection with preloaded projects. Some kits are especially designed for STEM high school students (Dextered, n.d., James, 2022, Home, n.d.). Example of such DIY kits are:

a) DIY Robocars
b) Duckietown
c) Formula Pi
d) Udacity Self Driving Car
e) Elcano Project
f) JetBot AI Kit
g) Robolink Zumi AI Self-Driving Car Kit
h) Picar-X

Figure 1: DIY 4WD Robotic Car: Robotics Learning Kit (Robot Pi Shop, n.d.)

AV KITS PLATFORMS

AV kits consist of hardware, software, cloud, and communication platforms. The accessories like chassis, wheels, battery holders, jumper wires, etc., are used to assemble the kit. Hardware platforms use the programmable circuit board also known as a microcontroller board. These boards receive the programs from the computer through an integrated development environment (IDE). IDE is the graphical user interface used to write a program and upload it to the board. These controller boards can be expanded using the expansion boards or breakout boards for additional features and functionalities or for easier connection and assembly of the kit. For example, if the hardware platform is Arduino Microcontroller, then expansion boards are called shields. These shields can be a motor shield, relay shield, LCD shield, ethernet shield, proto shield, CAN-BUS shield, smoke detector shield, GSM/GPRS shield, camera shield, etc. These shields add additional features to the board like ethernet, Bluetooth, camera, smoke detector, etc. The addition of several features and functions can demand higher processing power on the controller board. To support higher processing power on board, an edge control board can be used. Edge control boards support the deployment of artificial intelligence (AI) and machine learning on the board (edge) called AI edge processing. However, these kits can be limited by the budget constraints on the education kits.

The software platform is used to write customized code that can be uploaded to the controller board. These codes can be written in Java, Python, C, etc. Some vendors also provide prewritten code and tutorials. To control the board remotely, or to transfer and store the data, a cloud platform is used. Cloud or remote connection platforms use computer protocols like MQTT, CoAPP, http, etc. Communicating with the remote system requires network connectivity. This connectivity is provided by the network platform like Wi-Fi, Bluetooth, Zigbee, Z-wave, etc. These platforms are summarized in the Table 1.

AV KITS FUNCTIONS, FEATURES, AND USES

These DIY kits can support several functions, including object detection and recognition, cliff detection, lane following, path planning, etc. These functions generally divided into five categories: computer vision, sensor fusion, localization, planning, and control. To support these functions, it uses sensors. Sensors are made into ready-to-mount components called modules. The modules are available for all varieties of sensors. Among them, the camera module, ultrasonic sensor, and line tracking sensor are used to detect the color, obstacles, road signs, etc. The detection module are used to follow the track and react to the obstacles and the road signs. It can be used to detect the cliff so that it won't fall from the slopes. GPS module and compass module can be used to get the best position estimate of the robot kit.

These development kits are suitable for entry-level learners of AV or enthusiasts. These learners' groups can be STEM students, undergraduate students, or graduate students including research students. These kits can be further expanded by adding customized components. The platform, Duckietown, expands the kit with a customized list of components and parts to provide a most in-depth real-world experience of AVs. This platform is designed to support a wide range of functions at a low cost. Those functions are following lanes while avoiding obstacles, pedestrians (duckies), and other Duckiebots, localizing within a global map, navigating a city, and coordinating with other Duckiebots to avoid collisions (Paull, et. al., 2017).

These kits with expanded functions and features at the software or hardware levels, can be implemented or converted into real/practical world scenarios for example in detecting land mines, explosives etc.

Figure 2: Coimbra's Mine Detection Robot (Hennessey, M., 2015)

Some of the kits are designed for academic research for example Quanser's self-driving car research studio for the QCar. QCar is an open-architecture scaled model vehicle, powered with NVDIA® ® Jetson™ TX2 supercomputer, and equipped with a wide range of sensors, cameras, encoders, and user-expandable (Quanser, 2022).

Figure 3: The Self-Driving Car Research Studio and QCar (TecSolutions, Inc., n.d.)

The enhanced feature of the kits like QCar have on-board computing (OBC) chip. These on-board computing chip also known as Artificial Intelligence (AI) Edge Chip or Edge Control boards. These chips/boards deployment of artificial intelligence (AI) and machine learning on the board (edge) called AI edge processing.

These learning kits enables learning for various levels of learners. These learning process can be reinforced by participating in different kinds of AV or AI enhanced self-driving car leagues and competitions. Some of the leagues are listed in the Table 2.

Leagues	Descriptions
AI Driving Olympics	Held annually at the NeurIPS conference
Amazon DeepRacer League	Train and race low-cost ($300) Amazon 1/18th scale cars using AWS reinforcement learning
Self Racing Cars	San Francisco Area full-size cars and DIY Robocars events
Self Driving Track Days	Europe: test track and one-day training courses
F1/10 Racing	higher-end 1/10th scale cars with Lidar and Nvidia computer, started by U Penn. Starting cost around $3,000

Table 2: Self Driving Car Leagues and Competitions

4. BENEFITS AND FUTURE TRENDS

There are several benefits of adopting Learning AV Kits. Some of these benefits are as follows:

- There are many DIY or R2R kits available in the market based on the need and affordability.
- These kits are available for different age groups K12 to college students.
- These kits are suitable for any skill level from beginners to advanced.
- It does not require prior skills or knowledge. The kits come with step-by-step instructions set, and online tutorials or YouTube videos are also available.
- Most of the Kits come with cloud application integrations.

AV industries will create new jobs while other traditional vehicle industries will be greatly impacted which could cause a loss of more than four and a half million jobs worth $168 billion dollars of annual wages (UPCEA, 2017). In a study by the Institute of Transportation and Development Policy in 2017, there are three trends that, if adopted concurrently, would unleash the full potential of autonomous cars: vehicle automation, vehicle electrification, and ridesharing. By 2050, these "three revolutions in urban transportation" could (Synopsys, n.d.):

- Reduce traffic congestion (30% fewer vehicles on the road)
- Cut transportation costs by 40% (in terms of vehicles, fuel, and infrastructure)
- Improve walkability and livability
- Free up parking lots for other uses (schools, parks, community centers)
- Reduce urban CO_2 emissions by 80% worldwide

According to McKinsey & Company, there are three-time horizons of AV diffusion before such vehicles become commercially available to individual buyers when they are in the early stage of adoption, and when they become the primary means of transport illustrated in Figure 4. It is highly likely that jobs created related to AVs will also grow tremendously during these time horizons.

However, there are some variations among the researchers or agencies regarding the projected data in the next few decades, all those projections have high growth projections. From these, it is evident that AV projection in the next few decades will be an indispensable part of the modern transport system. To develop skilled manpower that can match with growth rate, it is urgent for the educational community to reform their curricula to ensure they cover diverse subjects that are required for AVs including software engineering, communication technologies, electrical engineering, etc (Bagloee, 2016, Chaudhury et al, 2016).

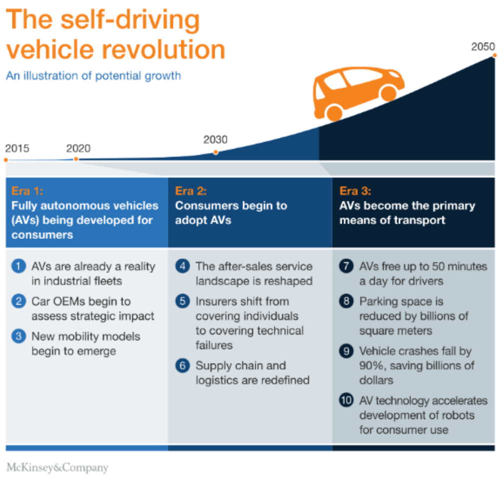

Figure 4: The Self-Driving Vehicle Revolution and the Three Eras of AVs (Bertoncello, M., & Wee, D., 2021)

5. CHALLENGES OF EDUCATIONAL IoT KIT

Currently, AVs are one of the major innovations being one of the areas with greatest potential for transformation of society and the economy in the coming decades. As such, all the involved stakeholders including developers, industries, educators, and consumers, face several challenges that remain to be tackled. Some of the challenges in the education system are as follows:

- Educators also have the challenge of adapting AVs into programs and curricula at a rapid pace to match the pace of adoption of the technology in the real world (Hadfield, C., 2020).
- Need to train students the individual components and sub-systems like lane following, road markings detection, obstruction detection, coding, etc. which may not fit a single course
- Educators' reluctance to adopt new technology.
- Educators may need to partner with employers/vendors to perform outreach to the multitude of careers with autonomous technology (Hadfield, C., 2020).
- There are many available DIY kits available in the market and it may be hard for the beginner to know which one to choose.
- The cost of the kits may range from $200 to $1000s. These costs may not be affordable for some students.
- Troubleshooting the hardware components could be difficult to diagnose for the beginner.
- Some devices and applications may not be compatible making them difficult to deploy.
- Students will learn the basic concepts of how autonomous vehicle works from the small-scale learning kits; however, the complexity of a real on-road autonomous vehicle is much greater and more robust.

6. CONCLUSION

Autonomous vehicle technology is on the horizon and widespread adoption of these technologies will grow rapidly over the next few decades as discussed in the self-driving vehicle revolution eras. These technologies will impact many sectors including government, auto industries, researchers, and educators, prompting them to seek new avenues of development and innovations and ways of adapting to these technologies. Educators need to incorporate or blend these topics into their existing courses. Small-scale learning kits could be the cost-effective solution that can speed up the learning process and the realization of the potential of AVs can soon be the profound reality of driverless cars in the smart world.

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