Development of Remote Operated Vehicle (ROV) Control System using Twincat at Main Control Pod (MCP)

Mohd Aliff, Nur Raihan, Ismail Yusof, Nor Samsiah

Abstract*: *The remote operated vehicle (ROV) basically tethered underwater robot. Thus, this research to replace the current PCB based in main control pod (MCP) which are not available in the production line into the Programming Logic Control (PLC) based. The new control system by using TwinCAT software and the network connection between ROV and PLC has been developed. In revamping the control system, it will allow for the ability to connect modules together with hardware and/or software modification. The maintenance cost of new control system is inferior compared to the existing PCB card. Moreover, the time required to conduct the maintenance is more inflective buy using PLC. For a real-time data monitoring, the ROV will used graphical user interface (GUI) to controlling the operation. The new control system performance is assimilated with existing control system in MCP at ROV.

Keywords*: *Graphical user interface (GUI), Main control pod (MCP), Programming Logic Control (PLC), Remote operated vehicle (ROV), Tethered underwater robot, TwinCAT software.

I. INTRODUCTION

Programmable Logical Controller (PLC) is industrial digital computer designed for automation and repetitive tasks in a harsh environment [1]. PLCs are used in many machines and robots, in many industries [2, 3], including industrial process control and industrial automation control. Modules can be added to PLC stack to provide enhancements capabilities and software can be quickly modified to fit with new operating requirements. PLC is widely used in factory, production plant, and water treatment facility for their dependability, durability, and easy interface for the program.

Robots have many advantages as used in numerous of tasks [4-9] and able to work in a dangerous environment [10]. For example, underwater robots are used for mapping the sea floor, military and surveillance, welding, inspections and assembly have seen remarkable growth [11, 12].

In last few years, the operational cost was rapidly debasement. Thus, Ordinarily, most underwater vehicle operations are the offshore industry is the biggest user of Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) [10].

Revised Manuscript Received on October 05, 2019.

Mohd Aliff*, Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur, Johor, Malaysia.

Nur Raihan, Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur, Johor, Malaysia.

Ismail Yusof, Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur, Johor, Malaysia.

Nor Samsiah, Center for Artificial Intelligence Technology (CAIT), Universiti Kebangsaan Malaysia, Selangor, Malaysia.

Controlled manually, with neither automated control functions or other motorized capabilities [13]. How bait, lots of studies had approved that automation can decrease the allotment including the expense of the operation and inclusion of actual entity that can be a compelling part of an motorized control-strategy.

As shown in Figure 1, at present, the underwater robot was plunge into two categories, depend on the purpose of the work involved [14, 15]. US Navy usually used the defination of UUV as synonymous with autonomous underwater vehicles (AUVs), despite the defination is non-standard in industry.

Generally, ROV are galvanized by tele-remote operation control over tether that hoockup into vessel, it carried out tasks by using ROV manipulator equipment upon arrived seabed [16]. Besides, AUV are provided with automated controller and sensors. It mainly correlated towards subsea inspection scope. Thus, a statistic stated AUVs are been flourish. For example, the ODIN [17] and REMUS [18] has been proposed as an influence vehicle.

The ROV will be opertaed either in fully automated (programmed or actual robust mission control) or with under nominal supervisory control and non-cable connected, but for data links it will used such as a fiber optic connection.

Most of researcher said that, the AUV is a untethered underwater vehicle, which were free from main cable and could run with pre-programmed or logic-driven course. The deviation among AUV and remote operated vehicle (ROV) was commenced of direct hardware (for communication and/or power) between vehicle and surface.

Anyhow, AUV perchance connected to subsea using direct communication through an acoustic modem, or (while on the surface) via RF (radio frequency) and/or fiber optic [19].

The ROV falls inward broad range of mobile robotic vehicles basicly known as “remote controlled mobile robots” [20]. Motion of vehicle can be automated logic direction or remote operator control depending on vehicle’s capability and degree of input from operator.

The power of the vehicle can be onboard (e.g: battery or engine powered), offboard (e.g: power deliver through conductors within the tether), or a hybrid of both (e.g: onboard battery powered with a power recharge transmitted remote through the tether).

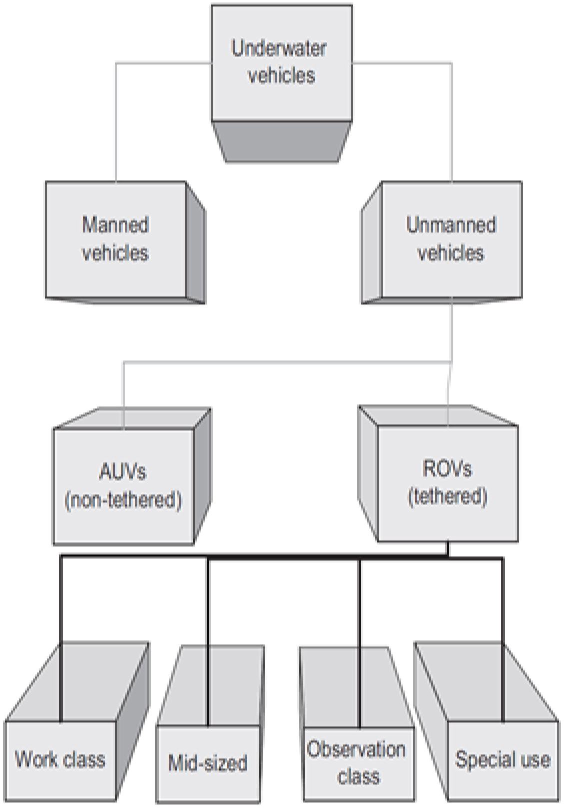

Fig. 1 Manned Underwater Vehicles and Unmanned Underwater Vehicles (UUVs)

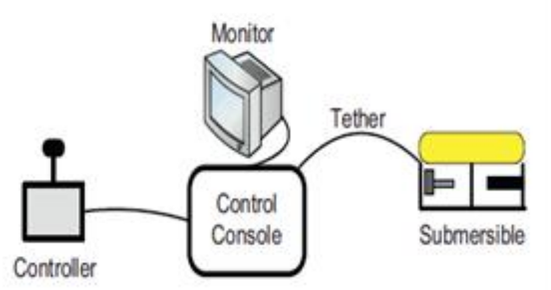

Fig. 2 Basic ROV components system

Figure 2, is basically a ROV mounted with camera in a aterproof enclosure, thruster for maneuvering attached tethered on surface for video signal and telemetry are trasmitted [21]. Nowdays, all of the vehicle in oil and gas industry, was used a standard industry regulation components which is known as "commercial off-the-shelf" (COTS) components.

As ROV goes from its simplest shallow water from towards the more complex deep water works vehicles, the required degree of sophistication of its operations as well as the depth of its support network climbs substantially in a similar fashion to that of aircraft or large surface vehicles [22].

The modern ROV was a mature technology with established standards of operator qualifications, safe operations and a proved history of getting work done in the "dull dirty and dangerous" work environments of the world's waters.

II. METHODOLOGY

In order to create new control system, it is required to prepare the input/output list that is well matched with current equipment and need to identify what type of hardware to be used to convert current PCB base to PLC base. This is involved combination of software and hardware based by using TwinCAT PLC software, PLC cards and MCP.

The new ROV control system architecture is created to enable rapid augmentation for advance of WROV systems, but it will contain a variety of modules as in Fig 4. The new control system will use different part of system architecture, including apportion safety-critical from non-safety-critical subsystems for cost-effective implementation and enhancement strategy of original WROV control systems.

Control console

The control console is the controls and monitors for ROV maneuvering, lights dimming, pan & tilt, camera selection, soft start, tooling, sensors, actuator and other functions are initiated by the pilot from surface control and response to a real-time command.

The new control systems by using TwinCAT software and PLC cards architecture, is similar to Hallin SCU software. Each programming in TwinCAT software and PLC cards at control console module will independently control the entire vehicle subsystem including power and data telemetry. Surface control computer will send the command to TwinCAT software and PLC card, thus, monitor the status, data report and instruments from ROV. Each data concentrated will operate synchronously and communicate to the surface control computer via fiber optic telemetry band-width.

New control systems architecture will employ a cinch on-vehicle computer system. This will simplicity of the data architecture design from PCB base to PLC which more highly reliable and easy to re-configurable. Figure 3, is one of the examples of work class ROV.

Surface control systems

The surface control system is the "brain" of ROV control system. It is comprised of "core" system of safety-critical systems that essential for safety and control of the ROV and as "extended" system providing non-safety-critical systems such as data logging and video recording. After upgrading, surface control system architecture still represent as per existing control system.

The safety-critical base systems are comprised of the vehicle control computer and user interface for the vehicle pilot and engineer. From pilot stations, it will provide a real-time video, navigation of instruments, joystick to control closed-loop control of vehicle, reference trajectories, navigation waypoints and controls for the vehicle's manipulator arms. Figure 4, basically is the engineer station. It has more comprehensive sets for a real-time vehicle status indicator and enables pilot to control all vehicle subsystems.

Retrieval Number: L40191081219/2019©BEIESP
DOI: 10.35940/ijitee.L4019.1081219

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Fig. 3 Work class ROV

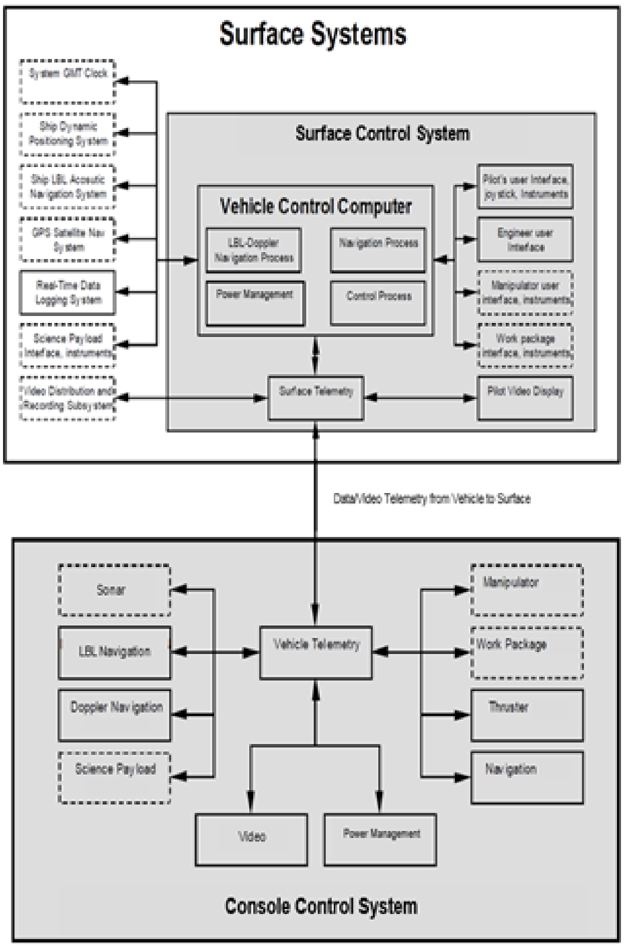

Fig. 4 New ROV Control System

Control console of computer was dramatically developed with simplest and accelerate intelligence for control and the new control system (reprogramming) on the surface control system is significantly easier to troubleshoot.

Fig. 5 Control Console

III. RESULT AND DISCUSSION

The focus is remodeling the control system of main control pod (MCP) that has been used in ROV based to PLC cards at WROV CROV 6. The results data is taken from real-time operation starting from year 2016 until 2018. This result will be explained about the control system before and after the modification. The result is shown in Fig 6.

Based on the Fig 6, this represents the real-time breakdown monitoring for the year of 2016 until 2018. The data was collected for the whole year performance. However, all the breakdown was indicating during operation hours. In particular, three years are observed - in order to prove the system reliability before and after modification.

In year of 2016 (before modification), it shows that it has a major breakdown for the whole project operation (whole year). This was caused by various factor such as former version of control system technology, high cost for maintenance, the existing PCB cards which are not available in the production line anymore as well as there was no supplier that can provide the spare

There was any other factor that can caused of the problem, which is during transportation of the spread from yard to the work site. Due to certain road condition, they were had a rough and have a high vibration that can affect to electronic device that may lead to unexpected problem occurred between the ROV and control van. This may cause the loosed electronic device connection at ROV and control van. For example, PCB control card, electronic device (fitted and spare) and others. Another similar situation that will cause the breakdown, were occurred during third party equipment installation. It may cause at the software problem (sometimes). For example, of third-party installation such as surveyor.

Retrieval Number: L40191081219/2019©BEIESP
DOI: 10.35940/ijitee.L4019.1081219

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

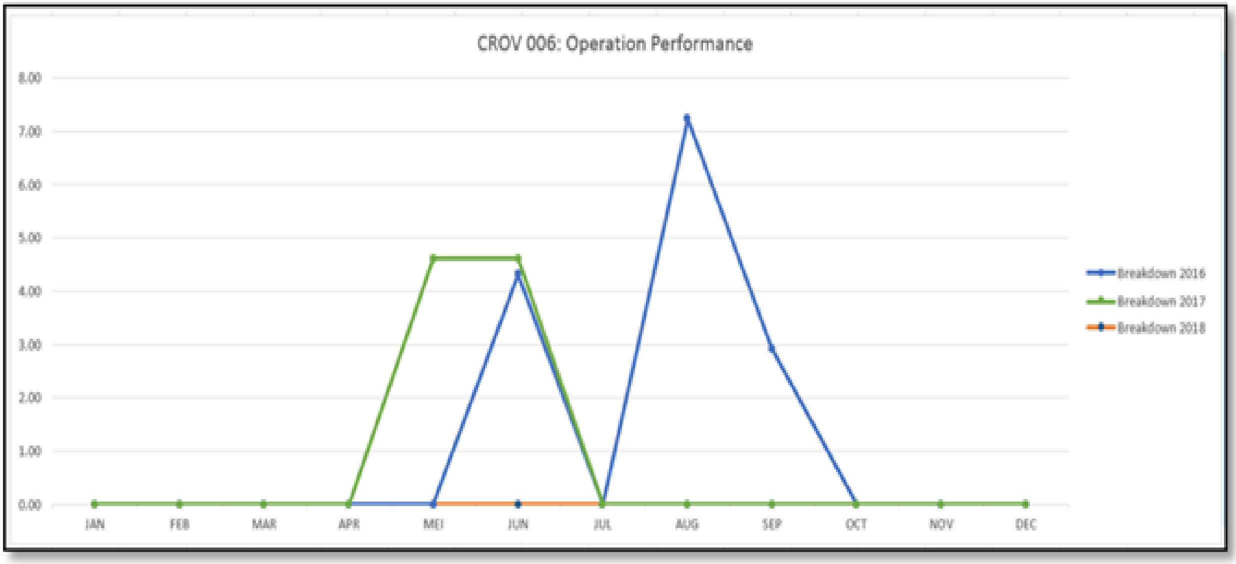

Fig. 6 Real-time breakdown monitoring from year 2016 – 2018

As per shown in the graph, the system was in the operation mode for four (4) projects between May until October. While in Jun, the system was on standby mode. Therefore, the system was not utilized and there was no breakdown recorded.

At some point in August, it shows that it had a high breakdown time recorded. Since the PCB cards are totally obsolete, they took lots of time to troubleshoot the overall system just to find the root cause of the problems encountered. This problem will continuous encountered unless there were had enough spare of PCB cards.

After end of the operation period, the system will be transported back from the work site to the yard for maintenance. During maintenance period, lots of problem were encountered, it caused a major problem and it will cost lots of money to resolve all the problem. Therefore, to solve all the problems, they decide to upgrade the system from PCB based to PLC base.

Thus, based on the graph, form January until April of 2017, there was the modification period for the new control system to take over. It was started with wiring and connection configuration (hardware) at MCP and at top site. Along with that, the PLC programming and configuration (software) was done concurrently. Since all the modification was take over concurrently, the duration to complete the wiring and connection of new control system reduce from the expected period.

After modification mode of control system (hardware and software) was completely done, now it was the period of troubleshooting to take over between months of May until June. During this period, the new control system (hardware and software) at MCP and top site were fitted at CROV 6 and had been tested. In this phase, lots of problem were encountered with the software configuration. The troubleshooting period will continuous ongoing until it reaches to the desired or better performance of the control system.

After all modification and troubleshooting was completely tested, now it was the time to test the new control system on the operation. On July until October, the system was in the operation mode for two (2) projects. Since this was the new control system and first time used in the industry, therefore, the new control system is monitored closely during operation. During the operation monitoring, there were no breakdown time was recorded after the modification was made. Thus, it can have an early summarize that the new control system was successfully achieved main objective of the problem is change the PCB base to PLC base.

In year of 2018 (after modification – monitoring mode), on June, the system was on the operation for one (1) project and shows that it has not recorded any breakdown with regards of the control system anymore. But performance of new control system still monitored closely during the operation until it reaches the probation period of 500 hours without breakdown.

As the results obtained in this thesis, this will conclude that it was a successful test of the new control system. In term of pilot/operator interface, this shows that it adequately conveys the new control system to the operator and facilitate real-time control of the vehicles. It was tested with an experienced ROV pilot and it shows that it could be easily learned with no prior knowledge of new control system since configuration and functionality are same as previous control system. The new control system showed that it had enough computerized and graphical performance to accurate the simulation of the complete system. It has been tested with experienced ROV pilots and they still can apply with the control methods they are accustomed to. As the result, in choosing the controller parameters that are appropriate for the given situation is the most important and must been taken care about the functional sensitivity.

IV. CONCLUSION

The objective of this project is to create a new control system which used of programming logic controller (PLC) technology for replace the existing PCB cards in main control pod (MCP) which are not available in the production anymore and allow for the ability to connect modules together with hardware and software modifications. This baseline system can used to control movement of the ROV.

Overall, new control system that using programming logic controller (PLC) cards, are the main method to measure. In order to provide real time data for comparing on hardware and software based, there was fully achieve because the condition of the new control system and the modification are meet exactly with the existing control system function.

ACKNOWLEDGMENT

This research work is supported by the Universiti Kuala Lumpur through Short Term Research Grant (STR18039). The authors would like to thank the research management centre of Universiti Kuala Lumpur, for managing the project.

REFERENCES

1. B. Greenspon, "ROV control system upgrade", in OCEANS 2015 - MTS/IEEE Washington, 2015, pp. 1-4.
2. A. Alheraish, W. Alomar, and M. Abu-Al-Ela, "Programmable Logic Controller System for Controlling and Monitoring Home Application Using Mobile Network", in 2006 IEEE Instrumentation and Measurement Technology Conference Proceedings, 2006, pp. 469-472.
3. M. Kabalan, D. Tamir, and P. Singh, "Electrical load controller for rural micro-hydroelectric systems using a programmable logic controller", in 2015 IEEE Canada International Humanitarian Technology Conference (IHTC2015), 2015, pp. 1-4.
4. M. Aliff, S. Dohta, and T. Akagi, "Control and analysis of robot arm using flexible pneumatic cylinder",Mechanical Engineering Journal.Vol.1, 2014, pp. DR0051-DR0051.
5. M. Aliff, S. Dohta, T. Akagi, and T. Morimoto, "Control of Flexible Pneumatic Robot Arm Using Master Device with Pneumatic Brake Mechanism",JFPS International Journal of Fluid Power System.Vol.8, 2014, pp. 38-43.
6. M. Aliff, S. Dohta, and T. Akagi, "Simple Trajectory Control Method of Robot Arm Using Flexible Pneumatic Cylinders", Journal of Robotics and Mechatronics.Vol.27, pp. 698-705,2015.
7. M. Aliff, S. Dohta, and T. Akagi, "Trajectory control of robot arm using flexible pneumatic cylinders and embedded controller", in 2015 IEEE International Conference on Advanced Intelligent Mechatronics (AIM), 2015, p. 1120-1125.
8. M. Aliff, S. Dohta, and T. Akagi, "Control and analysis of simple-structured robot arm using flexible pneumatic cylinders",International Journal of Advanced and Applied Sciences.Vol.4, 2017, pp. 151-157.
9. M. Aliff, N.S. Sani, M. Yusof, and A. Zainal, "Development of Fire Fighting Robot (QRob)",International Journal of Advanced Computer Science and Applications(ijacsa).Vol.10, 2019,pp.,.
10. S. Pedersen, T.T. Enevoldsen, and E.M. Einarsson, "Model comparison of a VideoRay Pro 4 Underwater ROV", in 2018 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), 2018, p. 899-904.
11. R.B. Wynn, V.A.I. Huvenne, T.P. Le Bas, B.J. Murton, D.P. Connelly, B.J. Bett, H.A. Ruhl, K.J. Morris, J. Peakall, D.R. Parsons, E.J. Sumner, S.E. Darby, R.M. Dorrell, and J.E. Hunt, "Autonomous Underwater Vehicles (AUVs): Their past, present and future contributions to the advancement of marine geoscience",Marine Geology.Vol.352, 2014,pp. 451-468.
12. C. Mai, S. Pedersen, L. Hansen, K.L. Jepsen, and Y. Zhenyu, "Subsea infrastructure inspection: A review study", in 2016 IEEE International Conference on Underwater System Technology: Theory and Applications (USYS), 2016, pp. 71-76.
13. I. Schjølberg and I.B. Utne, "Towards autonomy in ROV operations",IFAC-PapersOnLine.Vol.48, pp. 183-188,2015.
14. Y.S. Choi, "Underwater Robot Technology for Inspection.", in Underwater Robot a research body Workshop. 2006.
15. H. Robinson and A. Keary, "Remote Control of Unmanned Undersea Vehicles ",International Unmanned Undersea Vehicle Symposium, 2000,pp.
16. Z. Side and J. Yuh, "Experimental study on advanced underwater robot control",IEEE Transactions on Robotics.Vol.21, 2005,pp. 695-703,.
17. H.T. Choi, A. Hanai, S. Choi, and J. Yuh, "Development of an underwater robot, ODIN-III", vol.1 ,2003,pp. 836-841.
18. C. Von Alt, B. Allen, T. Austin, N. Forrester, R. Goldsborough, M. Purcell, and R. Stokey, "Hunting for mines with REMUS: a high performance, affordable, free swimming underwater robot", ,vol.1, 2001, pp.117-122.
19. U. Chakraborty, T. Tewary, and R.P. Chatterjee, "Exploiting the loss-frequency relationship using RF communication in Underwater communication networks", in 2009 4th International Conference on Computers and Devices for Communication (CODEC), 2009, pp. 1-4.
20. L. L. Whitcomb, "Underwater robotics: Out of the research laboratory and into the field". Vol. 1. 2000, 709-716 vol.1.
21. D.O.B. Jones, "Using existing industrial remotely operated vehicles for deep-sea science", Zoologica Scripta.Vol.38, 2009, pp. 41-47,.
22. R. Bishop, "Intelligent Vehicle Applications Worldwide",IEEE Intelligent Systems.Vol.15,2000, pp. 78-81.

AUTHORS PROFILE

Nur Raihan Ismail is currently a graduate student in Universiti Kuala Lumpur British Malaysian Institute (UniKL BMI). She received her BSc (Instrumentation and Control Engineering) from the Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur, Malaysia (UniKL MITEC). Her research topics is Reversed Engineering of Remote Operative Vehicles (ROV) Control System.

Mohd Aliff is currently a senior lecturer of Instrumentation and Control Engineering Section, Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur, Malaysia. He received his doctor degree in Engineering from Okayama University of Science in 2016. His research backgrounds are in mechatronics and robotics; particularly in rehabilitation device, intelligent robot and flexible pneumatic actuator. He is a member of Board of Engineers Malaysia and Malaysia Board of Technologists

Ismail Yusof is currently a Head of Section of Instrumentation and Control engineering, Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur, Malaysia. He received his Bachelor of Engineering Technology (Mechatronics) from the Universiti Kuala Lumpur-Malaysia France Institute (UniKL MFI) and PhD in Automatic Control & Systems Engineering from the University of Sheffield. His research interests in Control System with Application in Robotic.

Nor Samsiah is currently a senior lecturer at Faculty of Information Science & Technology, Universiti Kebangsaan Malaysia (UKM). She received her BSc (Information Technology) from the Universiti Tenaga Nasional, in 2004 and PhD from the University of Sheffield, in 2016. Her research interests are in machine learning and artificial intelligence.