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Use of Artificial Intelligence for Autonomous Military Robots

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***Abstract*— Defense and security has become a severe problem for the whole world. With the technological evolution, intelligent machines have been introduced to the military forces, having a purpose of reducing the causalities and deaths of soldiers. Features of Artificial Intelligence are massively involving with the development of the autonomous military robots. Decision making techniques, navigation and pattern recognizing abilities are embedded with the military robots. Although this application is really helpful to the community, it has some unavoidable reliability issues and security issues as well. In order to enhance the usability of this application, self- destructives robots can be developed. Reviewing applications of the Artificial Intelligence for autonomous military robots and finding its future directions is the main purpose of this study.**

Keywords—Artificial Intelligence, Autonomous military robots, Pattern recognition, decision making techniques

I. INTRODUCTION

Nowadays, defense and security have become a vital necessity in all over the world. Military forces have a huge responsibility to ensure the safety of their country. In past, military forces were straight away used soldiers for the combat operations. However, it was causing a lot of soldiers to lose their lives in the battlefield. In order to reduce causalities and deaths in the battlefield, modern military forces are using new technical weapons [1]. Autonomous military robots are the prominent technical weapon that military forces are supposed to use in the battlefield. Robots are preventing the intervention of soldiers to the battlefield. Autonomous military robots can execute their military operations by themselves. Additionally, they can make decisions of their own. Robots can hide for a long period of time without having foods during the combat operations. Autonomous robots are self-destructive when they caught by the enemies. Therefore, the confidential details of the mission are protected.

Artificial Intelligence gives the basis for most of the autonomous systems in the world. Artificial Intelligence acquire human mental skills such as pattern recognition, natural language understanding, ability of leading, ability of following a leader and adaptability to do the automation process more efficient manner. Perception, manipulation, reasoning, communication and learning are five steps of analyzing a problem by using Artificial Intelligence [2]. The ultimate solution produced by following the above five steps are an intelligent machine which is capable of decision making. Human mental skills are reproduced in Artificial Intelligence by using logical computations. In present, Artificial Intelligence is highly influenced to the applications in automobile industry, internet security, robotics and video games.

Battlefield scenarios are changing over the time. Hence the military robots should be quickly adapting to the environment and should get quick decisions as well [3]. In order to fulfill this requirement, Fuzzy logic of the Artificial Intelligence should be needed. Fuzzy logic helps for critical thinking and doing critical evaluations. Robots have assigned very tedious tasks therefore robots should be well equipped and well controlled. The deep learning concept of Artificial Intelligence can be used to control robots. This study focusses on various ways of incorporating Artificial Intelligence technology in autonomous military robots.

Second section provides an overview for the use of Artificial Intelligence in autonomous military robots. Third section describes the major researches of military robots. Fourth section is referring about the current issues regarding military robots. Fifth section is regarding the applications of autonomous military robots along with AI. Sixth section is providing a discussion and the seventh section is describing the future directions for the development of autonomous military robots.

II. OVERVIEW –ARTIFICIAL INTELLIGENCE FOR AUTONOMOUS MILITARY ROBOTS

Artificial Intelligence is a process of acquiring the skills of human to implement intelligent machines. With the

influence of AI, the robotic technology has been dramatically improved. Robot is an intelligent device which is capable of "think" and making decisions of its own.

Human thinking process is having an order of sequence. AI is also having a similar functionality applying to make decisions. Steps of the decision-making process is described in this section [4].

A. Perception

Perception is involving with creating models of the real world by acquiring sights, smells, sounds and touch from a sensory input.

B. Manipulation

Manipulation is the process of creating a model in a more realistic way by changing the acquired inputs from the previous step according to the real-world effects.

C. Reasoning

Reasoning is involving with drawing conclusions based on the manipulated inputs of the second step by using logical techniques. Reasoning is the most critical step of this process because in this step we apply complicated cognitive functions to derive conclusions.

D. Communication

Communication is basically realizing the given problematic scenario and output the processed data through a particular kind of language.

E. Learning

Learning stage improves the performance of the system based on the time. Learning can be done in several ways such as tuning, concept formation and discovery.

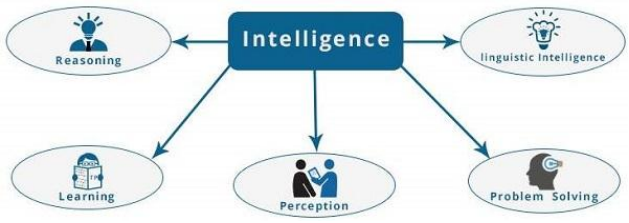

Fig 1: Mechanism to solve problems in AI

The ultimate product of this procedure is an intelligent machine. Artificial Intelligence gives the motivation for the "autonomy". Autonomy is a particular system is functioning by itself without the human interaction. This concept made a huge evolution in so many industries in the world. Lots of manual processes have been automated. With the development of the technology, people are trying to develop robots which is having similar capabilities of human. Strategies related to Artificial Intelligence is used to replace the skills of human to the machines. Military and defense industry also acquire robots to do their military tasks. Since the military tasks are more crucial and critical, military robots should be enough knowledgeable to handle those tasks.

There are some core features of military robots which can be developed with the help of the concepts in AI.

A. Algorithmic targeting

This can be used for rapidly identifying targets in the battle field. This feature is very useful for pilots for visually identifying targets. Deep learning analytics gives the basic approach to this target recognition. Further implement this system using Fuzzy Logic may help to process sensor data to plan quick and sharp combat movements [5].

B. Situational awareness and understanding

The environment of the battle field is always changing. Therefore, the robots should be able to adapt to the environment very quickly manner. In fact, robots should be developed with natural language processing systems, voice recognition capabilities and facial expressions recognition skills [5].

C. Automated planning and manpower allocation

Automated planning is currently identified as a limitation of Artificial Intelligence. Unlike humans, robots are dealing with the datasets of other types of robots according to the machine learning theorem. In order to allocate soldiers for missions, robots should be identified their capabilities and past records of soldier robots as well. Therefore, robots should be able to deeply understand any kind of situation before they are allocating soldiers to missions. AI provides a basic platform to this scenario [5].

D. Navigation by avoiding barriers

In order to detect the target, robot should avoid the barriers and find the optimal way to reach the target. Proper navigation should be happening in both day-time and night. Additionally, the robot could be able to identify barriers and could be capable of avoid or destruct those barriers as well [6].

E. Target classification and identification

Military robot should be capable of identify the type of the target to be attacked. Furthermore, military robots should be capable of handle radar system. Extract radar details is one of the most important part of that procedure. "Convolutional Neural Network" is the optimum way of extracting details. This method is having a deep learning approach [7].

F. *Knowledge modifying and updating*

Military agent should be regularly updated. "Object Oriented Fuzzy Petri Net" and "Colored Petri Net" approaches can be used to fulfil those tasks. Real battlefield has a dynamic environment. Therefore, the military agent should be updated their knowledge according to the current situation. Otherwise it will be affected to the decision-making procedure of the agent [8].

III. MAJOR RESEARCHES OF ARTIFICIAL INTELLIGENCE FOR THE AUTONOMOUS MILITARY ROBOTS

Recently, a considerable number of researches have been done in order to improve the quality and the capabilities of autonomous military robots. Studies have been proven that the concepts of Artificial Intelligence were greatly impacted to the evolution of autonomous military robots.

A. *Locomotion Control Strategy*

Hongchul Kim et al. have been discussed in their study about the locomotion strategies of a military robots. Locomotion means the strategies involving with the motion of the robots. Stable movements are some of the foremost features of a military robots. Otherwise their missions could have been failed. This study has been verified that the "dual-mode control" gives the best stability with fast walking when the robot is in a swing phase. Furthermore, the study has been proven that "virtual joint torque control" gives unstable motions when the walking speed is increased [9].

B. *Instance Base Learning Theory*

Varun Dutt has been discussed in his study about the concepts of IBL theory. IBL is an instance-based learning theory which has a method of storing past experiences as instances. When there is a decision-making situation, instances are retrieved from the memory and re use them according to the current situation. After 100 trials it has been proven that IBL theory is having reasonable accuracy [10].

C. *Intelligence Sensor System*

D.D.Weiner et al. have been emerged from their studies about an intelligence sensor system which can be used for military robots based on Artificial Intelligence algorithms such as Knowledge based algorithms and Signal and Data processing algorithms [11].

D. *Force Aggregation and Classification*

Hui-min chai and Bao-Shu Wang have been studied about a new approach to force aggregation and force classification with use of fuzzy belief networks. Fuzzy belief network is the most prominent way of knowledge representation by using production rule in Artificial Intelligence. "Nearest neighbor clustering algorithm" is used to implement force aggregation. Force aggregation conditions are applied based on the distance between two objects in the battlefield. Fuzzy belief networks involve to force categorization. In order to classify forces, fusion should be done to the level of force aggregation via fuzzy belief networks [12].

E. *Classifying Radar via Deep Learning*

Sara Zaied et al. have been discovered a method to classify "Synthetic Aperture Radar" and "Inverse Synthetic Aperture Radar" via Deep learning. "Convolutional Neural Network" is the way of identifying patterns in radar. Other than this method, "K Nearest Neighbor algorithm" and "RN" algorithm also have been tested for several cases. Finally, it was proven that the best solution for classifying radar is the CNN approach [7].

F. *Navigation Property*

Artem A. Lenskiy and Jong-Soo Lee have been studied about an approach which is used to determine the navigation property of the military robots. This strategy is based on the visual spectrum images captured by the CCD cameras. Conventional approach for autonomous navigation is "laser ranged finders". Since there is having some critical disadvantages, CCD cameras are used in this approach. Using CCD cameras, colored views of the surrounding can be captured. In order to separate the views of grasses, trees, and bushes which are having the same color, textures have been used. Since the textures cannot be extract in night time, IR spectrum is used to extract textures since IR spectrum is less affected by the shadows. That is the novelty of this approach [13].

G. *Vision Based Approach*

Mr. Sandeep Bhat and Dr. M. Meenakshi have been explored a vision-based approach for autonomous military robots. This mechanism is based on the "Sum of Absolute Different" algorithm. Moreover, principles of image subtraction are also been used for the implementation. This approach is mainly used for mines detection in the battlefield. This approach is tested in offline by using mathlab and real time testing is done by using "changed-based moving object detection method" [14].

IV. CURRENT ISSUES IN AUTONOMOUS MILITARY ROBOTS

There are some considerable issues regarding the autonomous military robots for combat operations along with the Artificial intelligence. S.Y Harmon and D.W gage have been studied three types of critical issues of military robots [15].

A. *Robot fault tolerance (reliability)*

Reliability is an unavoidable issue which can be arisen in any kind of technical field. If Artificial Intelligence provides a very responsive framework to the robotic technology, timing issues can be emerged. Every parts of the robot should be function on time. Otherwise it may result huge losses to the industry. Therefore, maximum fault of the military robots should be minimized.

B. *Robot security*

Security is one of the foremost features of military forces. If a robot was caught by the enemies, there can be resulting a huge risk of leaking the confidential data of the mission even the system is encrypted. Security terms of AI might be inadequate to the military robots while they were engaging in severe combat missions.

C. *Multi robot coordination*

Robots are not involving missions alone. Group of robots should be placed in a battlefield. Therefore, it may be resulting a huge replacement cost. Even though robots having a thinking capability, human should be involved to control the operations in severe combat missions.

Moreover, Gerard de Boisboissel have been discovered within his study that relying on the decisions made by the autonomous military robots might be risky [16]. They are as follows.

A. *Decision making procedure*

Even though the autonomous military robots are expected to be functioned by themselves, without getting any human interaction, that concept of autonomy can be applied only up to a certain degree in real world scenarios. Combat operations are very complex and very risky. Therefore, most of the military robots have been teleoperated via human control. In autonomous systems, decision making is a pattern of "perception-decision-action". This procedure is more abstract because it is very hard to replace the brain power of the real human by using Artificial Intelligence. In reality, it may be a risk of depending on the decisions of the autonomous robots since their decisions might be based on the previous scenarios which they have stored in their memory. Decisions based on previous scenarios might not be applicable to the current situation. Therefore, constant supervision under a real military leader has become an essential requirement for the military robot industry.

Shannon Vallor has been referring his studies about an issue regarding autonomous military robots which is currently being affected [17].

B. *Moral deskilling of the profession of military agent*

This issue is considered as an ethical issue. Real professionals in military industry are facing a problem of the legality of introducing autonomous military robots to the real war field. Additionally, the courage, spirit and the strength of the military forces may decline since their services have been replaced from the autonomous military robots.

V. APPLICATIONS OF AUTONOMOUS MILITARY ROBOTS

Robotic technology has become a hot topic within the community after the improvement of the Artificial Intelligence. People tend to use robots for reducing their workload. Military forces also began to use intelligence machines for their missions in order to reduce the causalities and deaths of the soldiers.

A. *Multipurpose Military Robot*

S. Pavithra and S.A. Siva sankari have been recently implemented a multipurpose military robot with remote monitoring and intruder detection facility. Intruder detection facilitates face recognition [18].

B. *Telepresent Rapid Aiming Platform*

Javid Kurshid and Hong Bing-rong have been studied about the TRAP (Telepresent Rapid Aiming Platform) which is capable of shooting to the enemies from the hidden places [1].

C. *"Throwbot" Application*

Danna voth has been reported that the US Robotics Institute has been launch an unmanned vehicle called "Throwbot" which can be thrown to the buildings and scanned the whole area at once. This may be helpful for soldiers to ensure their safety before entering in to a building. A prototype version of a "Throwbot" was used for the military purposes in Iraq [19].

D. *"Talon" Application*

The study of the Danna voth has been reported that the US Defense Department has been used a lethal weapon called "Talon" for search and recovery missions. Over

100,000 "Talon" robots were deployed for the missions in Iraq [19].

Fig 2: Throwbot

E. *Radio Frequency Controlled Autonomous Military Robot*

Saradindu Naskar et al. have been studied about how to use the radio frequency controlled autonomous robots for combat operations. The most significant feature of this robot is "backtracking". If the signals coming from the base station is disconnected, this robot will start its backtracking process and try to receive the disconnected signal. On the other hand, these types of military robots are cost effective and can be used to earn more profits as well [20].

F. *Military Robot as a Baggage Carrier*

Sandeep Bhat and M. Meenakshi have been explored an approach for a military robot which can be used as a baggage carrier. Basis for this innovation has been taken from the path planning strategies which were used to create robots for watering. IR sensors have been used to identify the obstacles. Until the IR beam reflected from the surface of the obstacle, robot is moving forward. This robot can achieve to the target by using the optimal path by avoiding barriers (obstacles) [6].

G. *Multipurpose Robot for Reconnaissance*

Somen Nayak et al. proposed a multi purposed robot to be used in the battlefield. This robot is mainly focusing on reconnaissance and can be controlled through Bluetooth. Live video streaming can be fulfilled through web server connection in this system. Ultra sonic sensor provided 2D mapping. Additionally, grippers are functioning according to the commands which the controller is given. Grippers are basically used to destruction of bombs [21].

Studies have been proven that large no of robotics applications and intelligent machines are involving to the battlefield situations in order to assure the safety of the community. Although AI is helping to stop the warfare, "killer applications" can be emerged in future as a bad effect of this technology [22].

VI. CONCLUSION

This study reveals that Artificial Intelligence was massively impact to the field of autonomous military robots. Concepts of Artificial Intelligence helps to implement the intelligence features of the military robots. Some of the researches regarding the uses of Artificial Intelligence of military robots are describing the constraints and the future developments regarding autonomous military robots

VII. FUTURE DIRECTIONS OF AUTONOMOUS MILITARY ROBOTS

Technologies related to artificial intelligence are updating regularly. Therefore, new features could be added to the existing military robots in order to get more accurate results. However, these technologies should not be a reason to increase the terrorism. If these military robots use for a bad purpose, the whole community of the world can be a victim of the terrorism.

This study was identified few areas to be further developed.Increase the thinking capacity and speedup the decision-making process of the existing military robots. Since the battlefield environment is always changing, military robots should be quickly decided the upcoming operations. Current applications become unstable when increasing the speed of it. Moreover, this study suggested to develop self- destructive robots in order to ensure the secrecy of the confidential data. Furthermore, it is better to increase the range of the load that can be hold by a robot at one time. Another suggestion is to use Artificial Intelligence along with the neuroscience to implement robots which is having a good decision-making capacity. Additionally, this study suggested to use Super Artificial Intelligence techniques to develop incredible and more powerful military robots [23].

Additionally, this study is suggesting improving the testing and validating algorithms in multi robotics software [24]. Also, it is better to modify the software which is related to autonomous air crafts in order to ensure the reliability of air crafts [25].

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REFERENCES

[1] J. Khurshid and H. Bing-rong, "Military Robots - A Glimpse from Today and Tomorrow," in *Control, Automation, Robotics and Vision Conference, 2004. ICARCV 2004 8th*, Kunming, 2004.

[2] G. Nugroho, A. A. Rafsanjani, M. Satrio, R. Ramadhan and T. Sadewo, "Avionic System Design Unmanned Aerial Vehicle for Disaster Area Monitoring," in *Int'l Conf. on Advanced Mechatronics, Intelligent Manufacture, and Industrial Automation 2015 (ICAMIMIA 2015)*, Surabaya, 2015.

[3] M. Pradhan, A. Tiderko and D. Ota, "Approach Towards Achieving Interoperability between Military Land Vehicle and Robotic Systems," in *Military Communications and Information Systems (ICMCIS), 2017 International Conference on*, Oulu, 2017.

[4] C. Williams, "A brief introduction to Artificial Intelligence," in *OCEANS '83, Proceedings*, San Francisco, 1983.

[5] S. D. Spiegeleire, M. Maas and T. Sweijs, Artificial Intelligence for future defense, The Hague: The Hague Centre for Strategic Studies, 2017.

[6] S. Bhat and M. Meenakshi, "Embedded System Based Waiter and Military Robot Path Planning," in *2018 4th International Conference on Advanced Technologies for Signal and Image Processing (ATSIP)*, Sousse, Tunisia, 2018.

[7] S. Zaied, A. Toumi and A. Khenchaf, "Target Classification Using Convolutional Deep Learning and Auto-Encoder Models," in *2018 4th International Conference on Advanced Technologies for Signal and Image Processing (ATSIP)*, Sousse, Tunisia, 2018.

[8] X. Li, X. Liu, K. Li and X. Xie, "Military command entity agent modeling using petri net approach," in *2010 IEEE International Conference on Advanced Management Science(ICAMS 2010)*, Chengdu, China, 2010.

[9] H. Kim, C. Seo, Y. J. Shin, J. Kim and Y. S. Kang, "Locomotion Control Strategy of Hydraulic Lower Extremity Exoskeleton Robot," in *Advanced Intelligent Mechatronics (AIM), 2015 IEEE International Conference on*, Busan, 2015.

[10] V. Dutt, "Modeling a Robotics Operator Manager in a Tactical," in *Cognitive Methods in Situation Awareness and Decision Support (CogSIMA), 2011 IEEE First International Multi-Disciplinary Conference on*, Miami Beach, 2011.

[11] D. Weiner, M. Wicks and G. Capraro, "Waveform Diversity and Sensors as Robots in Advanced Military," in *Waveform Diversity & Design Conference, 2004. WDD2004 2004. International*, Edinburgh, 2004.

[12] H.-M. CHAI and B.-S. WANG, "A FUZZY LOGIC APPROACH FOR FORCE AGGREGATION AND CLASSIFICATION IN SITUATION ASSESSMENT," in *2007 International Conference on Machine Learning and Cybernetics*, Hong Kong, China, 2007.

[13] A. A. Lenskiy and J.-S. Lee, "Terrain images segmentation in infra-red spectrum for autonomous robot navigation," in *International Forum on Strategic Technology 2010*, Ulsan, South Korea, 2010.

[14] S. Bhat and M. Meenakshi, "Vision Based Robotic System for Military Applications – Design and Real Time Validation," in *2014 Fifth International Conference on Signal and Image Processing*, Bangalore, 2014.

[15] S. Harmon and D. Gage, "CURRENT TECHNICAL RESEARCH ISSUES OF AUTONOMOUS ROBOTS EMPLOYED IN COMBAT," in *Proceedings of EASCON 1984: 17th Annual Electronics and Aerospace Conference Washington DC, 11-13 September 1984, pp 215-219*, Washington, 1684.

[16] G. d. Boisboissel, "Is It Sensible to Grant Autonomous Decision-Making to Military Robots of the Future?," in *2017 International Conference on Military Technologies (ICMT)*, Brno, Czech Republic, 2017.

[17] S. Vallor, "The Future of Military Virtue: Autonomous Systems and the Moral Deskilling of the Military," in *2013 5th International Conference on Cyber Conflict (CYCON 2013)*, Tallinn, Estonia, 2013.

[18] S. Pavithra and S. Siva sankari, "7TH Sense-A Multipurpose Robot for Military," in *Information Communication and Embedded Systems (ICICES), 2013 International Conference on*, Chennai, 2013.

[19] R. L. Deuel, "A new generations of military robots," *IEEE Intelligent Systems*, vol. 19, no. 4, pp. 2-3, 2004.

[20] S. Naskar, . S. Das, A. K. Seth and A. Nath, "Application of Radio Frequency Controlled Intelligent Military Robot in Defense," in *2011 International Conference on Communication Systems and Network Technologies*, Katra, Jammu, India, 2011.

[21] S. Nayak, K. Shaw, J. Choudhury, A. Chakraborty, A. Iqbal, T. Kar, S. K. Bera, S. Saha, D. Deb, D. Roychoudhury, D. Mukherjee, R. Dey and S. Dey, "Unmanned Multifunction Robot for Industrial and Military Operation over Resource Constrained Networks: An approach," in *2017 8th IEEE Annual*

Information Technology, Electronics and Mobile Communication Conference (IEMCON), Vancouver, BC, Canada, 2017.

[22] P. Lin, G. Bekey and K. Abney, Autonomous Military Robotics: Risk, Ethics, and Design, California: Ethics + Emerging Sciences Group at California Polytechnic State University, San Luis Obispo, 2008.

[23] M. Cummings, "Artificial Intelligence and the future warfare," in *International Security Department and US and the Americas Programme*, 2007.

[24] A. Komenda, J. Vokrˇínek, M. Cˇáp and M. Peˇchoucˇek, Developing Multiagent Algorithms for Tactical Missions Using Simulation, vol. 28, IEEE Computer Society, 2013, pp. 42 - 49.

[25] J. G. Blich, "Artificial Intelligence Technologies for Robot Assisted Urban Search and Rescue," in *Elsevier Science Ltd*, Great Britain, 1996.

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