Integration of Artificial Intelligence in Unmanned Military Combat Platform

Utkarsh Vitthalrao Savkare
Department of Mechanical Engineering
Rajarshi Shahu College of Engineering, Pune, Maharashtra, 411 033, India

Abstract— Intelligent unmanned mobility systems are some of the most important application of Artificial Intelligence (AI). Development of such systems can significantly increase the innovation and integration of AI in military application. This paper introduces the base for use of AI in military autonomous systems, its evolution in past, current extent of AI included in the unmanned military systems. Furthermore, it is discussed about the possibilities and ways to increase the role of AI in these systems. Introduction to a new concept of AI integrated Humanoid Combat Robotics.

Key words: Intelligent unmanned Mobility Systems, Artificial Intelligence (AI), Military Autonomous Systems, Humanoid Combat Robot

I. INTRODUCTION

One of the basic principles for any military in a combat scenario is strategy and tactics. This principle can be successfully implemented, only if there is a proper decision-making system. War is too serious a matter to entrust to military men (Georges suarez, 1932). Therefore, a need of an unbiased, mentally strong system has emerged. The very solution to this problem is an intelligent, interacting, decision- making system. But if there is a human intervention in any of system, perfection can never be accomplished. Hence concept of artificial intelligence is formulated. Mobility in terms of military is the ability to move a weapon system or a combat unit towards the specified military objective. The military operates in all the three terrains air, water and land. Due to these terrains, sometimes it is difficult to transport the required weapons or armed units to desired position. In such a scenario, an unmanned system (mostly drones or UAVs) equipped with AI can be used for combat without any losses of life and property along with most accuracy which would rather not possible due to human limitations. An AI based mobility system has the ability to collect and interpret the data and act accordingly to give maximum output with least loss of resources.

Compared with traditional mobility systems, there is a wide scope for advances in AI integrated mobility systems. Many of the military applications like unmanned rovers, unmanned aerial vehicles and marine robots can achieve more autonomy, manoeuvrability and accuracy in their respective fields, if AI is implemented as the prime controlling unit. As of today, many unmanned systems are controlled by a human operator(s) due to which the productivity of these unmanned systems is limited. In this paper, we discuss the various development trends in integration of AI in the military mobility systems by summarizing the past developments in this area. Various possible techniques we can use to integrate AI in the unmanned systems. Exploring Different areas of application where these systems can be implemented.

II. BASE OF INCLUSION OF AI IN UNMANNED AUTONOMOUS SYSTEM

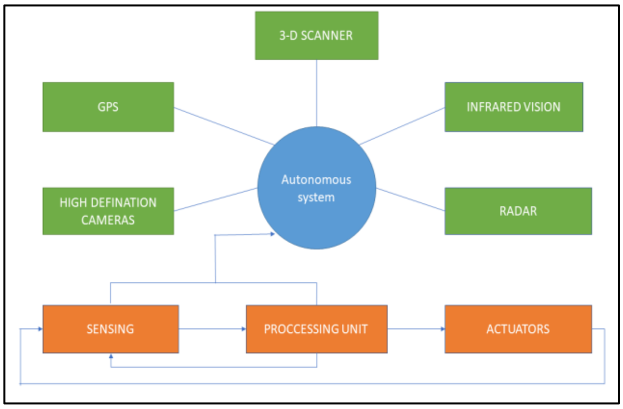

Fig. 1: Working Of AI in Autonomous System

One of the basic steps of including AI in any system is to develop such a program or software which is able to gather the data and process it in the same fashion as that of humans. This quality of human brain is necessary for the program so that it can replace the human work (manual input). Therefore we use an advanced model of hardware with more improved capabilities which include high definition cameras, hyper sensitive frequency interceptors.

Once the system can sense the surrounding, the next important aspect of the AI is to interpret the collected data according to the specified need of applications. This process is termed as 'Machine Learning'.

Machine learning has supported unmanned autonomous systems in two ways: providing perception and control similar to human interaction with the outside world, by first receiving information and then analyzing and controlling it. Sensory perception such as vision, acoustics, and tactility represent information sources from the outside world. Models are needed to transform the information into different levels of abstraction to describe the environment. When the information has been obtained, unmanned systems can learn to control actions using reinforcement learning mechanisms (Sutton and Barto, 1998) by evaluating rewards from the environment with which they interact and then choosing the best policy. Inspired by the hierarchical architecture of the human visual cortex (Hubel and Wiesel, 1962), architectures for multiple convolution-pooling layers have been proposed and are being used in different machine learning tasks. For vision processing (Fig. 2).

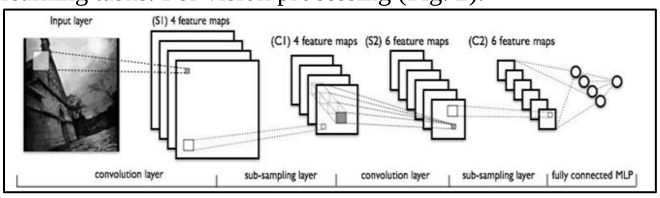

Fig. 2: Vision processing using convolution layers

The steps which are calibrated by using machine learning are implemented by actuator system, which performs suitable movement or action.

III. EVOLUTION TRENDS OF AI IN MILITARY SYSTEMS

The Hewitt-Sperry Automatic Airplane was the first very application of intelligent system in military during World War I (September 1917). It is considered as the precursor of the cruise missile. The ASM-N-2 Bat developed by National Bureau of Standards (NBS) for United States Navy was the first of radar guided glide bomb to be commercially produced remotely controlled form a radar station. It was first used in 1942. The most applauded example of AI integrated warhead delivery application is 'Fire -and- forget' missiles which do not require further guidance after launch such as illumination of the target or wire guidance. After it is fired the missile guides itself by some combination of gyroscopes and accelerometers, GPS, organic active radar homing and infrared homing optics. The first of such weapon to enter active service was de Havilland Firestreak developed by United Kingdom in 1957. Till today there are many development programs dedicated to make these missiles more autonomous.

On the contrary the development of Unmanned Vehicles (UV) was comparatively slow. Though Unmanned Aerial Vehicles (UAVs) were introduced in US military in 1917 (OSD, 2002), development of land and marine unmanned vehicles was stagnated till 2000s. Therefore from 2004 to 2007, the American Defence Advanced Research Project Agency (DARPA) organized three UV challenges which promote radical development of UV technologies (Montemerlo, 2008). In China, the National University of Defence Technology of China developed Hong qi CA7460 autonomous driving car with an autopilot reaching a speed of 130 km/hr and a maximum speed of 170km/hr on highway, with passing ability on road (Huang, 2010). In 2014 the General Reserve Department of People's Liberation Army (PLA) organized an unmanned ground vehicle challenge for off-road environments (Shi and Liu, 2014).

Due to the development of UVs, many derivative technologies have been applied to real applications. For example, the tactical UVs of the United States Marine Corps (USMC) can execute missions such as reconnaissance, nuclear biological chemical (NBC) detection, break down barriers, and direct anti-sniper shooting in any weather or in complex terrain. Carnegie Mellon University has developed a new kind of UV 'crusher', which can drive in complex environments. Since the beginning of the wars in Iraq and Afghanistan, about 8000 unmanned ground vehicles of various types have been involved in the missions 'Operation Enduring Freedom' and 'Operation Iraqi Freedom'. Until September 2010, these unmanned ground vehicles had performed 1,25,000 tasks, including suspicious target identification, road cleaning, and positioning and removal of improvised explosive devices (IEDs). The U.S. Army, Navy, and Marine Corps explosive demolition teams have used unmanned ground vehicles to detect and destroy more than 11000 IEDs.

Despite all these technological developments there are considerable problems including situational awareness in real time environment, intelligent decision making, system assessment techniques, system reliability.

IV. CURRENT EXTENT OF AI INCLUDED IN UNMANNED MILITARY SYSTEMS

The current areas of Unmanned Military System covered by AI are limited to surveillance and security rather than combat oriented. These systems too have human in loop, for example a drone used for surveillance can calibrate its position, speed etc. but is not capable to respond to any sudden threat without human commands.

Other applications in military security are Close-In-Weapon System (CIWS), Active Protection System. These types of system have a certain higher degree of freedom for the AI to operate in its functioning. The CIWS detects and engages the threats like short-range incoming missiles and enemy aircraft which have penetrated the outer defences. Whereas the Active Protection System is a system designed to prevent line-of-sight guided missiles or projectiles for acquiring or destroying a target. It uses electronic countermeasures that change the electromagnetic and acoustic features of the target to corrupt the tracking and sensing behaviour of the guided missiles/projectiles.

The Unmanned Aerial Vehicles (UAVs) can perform certain vigilant tasks like facial recognition, vocal recognition by comparing the database. According to the 'Unmanned Aircraft System Roadmap 2005–2030' published by the U.S. Defence Department in 2005, the current autonomous level of military UAVs is lower than level 3 (OSD, 2005). They do not have autonomous capabilities for route planning, decision-making, coordination, and cooperation.

The Autonomous Underwater Vehicles (AUVs) and Remotely Operated Underwater Vehicles (ROVs) are used in navy for marine surveillance. Almost all marine robots, no matter whether they are ROVs or AUVs, are equipped with several kinds of sensors to collect environmental data, such as forward sonar, side scan sonar, and altimeters. However, not all are capable of extracting valuable information from the data. It is reported that the REMUS and the Bluefin, which have been adopted by the U.S. Navy, are able to avoid possible collisions and to recognize specific objects. However, even with typical mine detection tasks, there are still many problems needing to be solved.

The terrestrial military robots are used by army at very small scale and are at very primary stages of development to be completely reliable and deployed in the war zones. The Gladiator Tactical Unmanned Ground Vehicle (TUGV) is used to support the United States Marine Corps to perform reconnaissance, assault and breaching missions. But it is radio-operated and depends on human input at every stage of operation. MIDARS, a four-wheeled robot outfitted with several cameras, radar and possibly a firearm, that automatically performs random or pre-programmed patrols around a military base or a government installation. It alerts the overseer when it detects movement in unauthorized areas or operates according to the programmed conditions.

Today GUARDIUM is the only commercially used autonomous Unmanned Ground Vehicle (UGV) used by

Israeli army. It does not require human interaction in its autonomous mode. The vehicle is equipped with infrared sensors, radars, high-sensitivity microphones, visible sensors, and hostile fire indicators. It is pre-programmed to drive itself along the routes given to it. With powerful sensors, it can detect and avoid unpredicted obstacles along with its infrared camera that helps spot any invaders in the dark. When it goes off road the cameras help it travel in any kind of terrain and weather. In its autonomous mode, it can set to a certain location or can be put on a ground path and it will cover its designated area until needed or for up to 103 consecutive hours. This mode is beneficial since it can sense abnormal circumstances and avoid them.

The arguments of the certain intellectuals on the safety and reliability of systems equipped with AI is the main factor that accounts for the limited use of AI in military rather than the technological developments.

V. Possibilities & Methods to Increase the Role of AI in Military Combat Systems

As of 2017 the challenges that are considered in field of AI are capabilities to successfully understand the human speech, intelligent routing in content delivery networks, military simulations and interpreting complex data including images and videos.

Approach towards AI development is divided into three parts namely computational psychology, computational philosophy and computer science (Shapiro, Stuart C., 1992) Computational psychology is used to make computer program mimic human behaviour. Computational philosophy is used to develop an adaptive, free flowing computer mind. Implementing computer science serves the goal of creating computers that can perform tasks that could be previously accomplished only by humans. Together the humoresque behaviour, mind and actions make up artificial intelligence.

The conventional ways for machine learning in any computational system are:

1) Decision tree learning.
2) Association rule learning.
3) Artificial neural networks.
4) Deep learning.
5) Inductive logic programming.
6) Clustering.
7) Bayesian networks.
8) Representation learning.

All these above techniques of machine learning convert all the process in mathematical or statistical logic. But all the intellectual thinking and reasoning taking place in the human mind cannot be formulated in mathematical equations. This is where machine intelligence is distinguished for that of humans.

To enhance machine intelligence a new method of machine learning is introduced in recent years called as DNA computation. DNA computing is a branch of computing that uses molecular biology, biochemistry and DNA fluids. The complexity of all living orgasms is based on the individual coding system of DNA molecule. Hence, the DNA is very suitable as a medium for data processing (Amos, Martyn; et al. 2002). According to current status the data capacity of 1 gm of DNA is 215 petabytes (215 million gigabytes). This extensive data density can be the solution for the limitations of data storage. The DNA strands are the most importance source of human intelligence, therefore use of DNA computing in AI systems will bring reduce the gap between human and artificial intelligence to the most possible extent. The DNA computing device can be built with basic logic gates like AND, OR, NOT associated with digital logic for the DNA. The different methods of using DNA in computing are classified according to the medium used:

A. DNAzymes

deoxyribozyme or DNAzymes are used to build logic gates similar to digital logic gates in digital circuits.

B. Enzymes

enzymes based DNA computers are used to build basic Turing machines. The DNA acts as software whereas enzyme acts as hardware of the system.

C. Toehold Exchange

in this system, an input DNA strand binds to another DNA strand at toehold which provides displacement of the consecutive DNA strand segment allowing formation of modular logic components like AND, OR, NOT gates and signal amplifiers.

D. Algorithmic Self-Assembly

DNA plates can be designed by using nanotechnology. These multiple DNA tiles connected to each other can be used for computing non-repeating bidimensional data sets.

Selection of DNA with specific capabilities like strategic planning, tactical skills and strong decision –making can help AI be compute according to human natural instincts.

Another method to enhance the capabilities of AI integrated systems is to implement Modelling and Simulations. Modelling refers to physical or mathematical representation of a system and simulation is method of implementing a model to develop data on the basis of technical decision making through exercise called as simulation governance (Szabo B. and Actis R .2011). Simulation governance gives the reliable analysis, best fit training and most optimized experimentation for a sample model system. Modelling and simulations facilitate understanding of a system without actual testing of the system in the real world. Simulations can be used to train AI using virtual environment that would be otherwise be difficult or expensive to produce. War simulations in a virtual environment can train AI to carry out the objective procedures with various constraints as well as provide insight of the behaviour of the system in these environments. Once the behaviour of system is analysed it is very easy to manipulate the system according to the specific needs to achieve objectives with most accuracy. Several Autonomous mobility systems such as Unmanned Aerial Vehicles (UAVs), Autonomous Underwater vehicles (AUVs) and Unmanned Ground Vehicles (UGVs) can be trained in such type of war simulations in various terrains. For example, UAVs like drone can be trained to deliver the payload at desired place under hostile fire and enemy air defence. Another use of war simulations in virtual reality can help AI to predict the most efficient route for missiles and also area of impact and its consecutive effects.

VI. AI EQUIPPED HUMANOID COMBAT ROBOT

The humanoid robot would completely revolutionize the mobility in military combat system. Instead of implementing humans for war and other military operations, a humanoid robot will be capable of performing all these tasks with great precision and accuracy outstanding human soldiers. The intelligence of human brain is evolved linearly throughout the process of evolution, but that of computer intelligence has just evolved exponentially in last 110 years. The performance of a computing integrated circuit doubles every 18 months (Moore, Gordon E. 1965). This difference shows how Artificial Intelligence can develop at higher rate than that of human's.

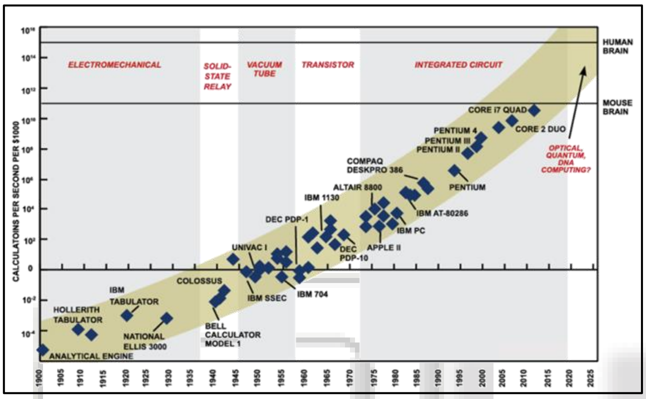

Fig. 3: Evolution of Computing

Machines don't get exhausted. A human's attention to detail on guard duty drops dramatically in the first 30 minutes (Major Kenneth Rose, BBC News .2002). The humanoid combat robot has advantages regarding the lack of emotion and passion that can be beneficial in reducing instances of unethical behaviour in war. These robots will comply with the laws of war (LOW) and rules of engagement (ROE). Hence the fatigue, stress, emotion, adrenaline etc. that affects a human soldier's rash decisions are removed (Patrick Lin, Keith Abney, George Bekey, 2009).

According to the technical aspects today most of the humanoid robots struggle to carry out bipedal motion and effective calibrations of centre of gravity for balancing. A very few humanoids are today able to perform movements and dynamic motions like running and jumping as of humans like FEDOR (Final Experimental Demonstration Object Research) and ATLAS. The FEDOR is a Russian humanoid that is capable of staying balanced while shooting guns. Whereas ATLAS is developed by Boston Dynamics is more oriented towards the search and rescue operations in military. Though these humanoids are not capable to be sent in the war zone at this instant but if a developed AI system is integrated in these humanoids these will be surely future soldiers instead of humans. The AI humanoid robots will have more load carrying capacity, more accuracy while firing a fire arm, ability to move in hostile conditions. These robots can operate in conditions like nuclear winter and biological war, in which it is impossible for human solider to operate.

VII. CONCLUSION

In this paper, we discussed the need of Artificial Intelligence in military systems, the current status of AI in these military systems, various possible ways to increase the autonomy of AI and concept of AI equipped Humanoid Robots. There is a wide scope of development in AI for autonomous systems. According to the current trends, the nation with the most developed AI integrated military will dominate the globe and can save lives of innumerable soldiers and serve mankind in keeping world peace.

REFERENCES

[1] Amos, Martyn; et al. (2002). "Topics in the theory of DNA computing". Theoretical computer science.287 (1): 3-38.
[2] Georges Suarez, 1932. La vie orgueilleuse de Clemenceau t.1 Clemenceau. Dans la melee, Paris, J. Tallandier.
[3] Hubel, D.H., Wiesel, T.N., 1962. Receptive fields, binocular interaction and functional architecture in the cat's visual cortex. J. Physiol., 160(1):106-154.
[4] Montemerlo, M., Becker, J., Bhat, S., et al., 2008. Junior: the Stanford entry in the urban challenge. J. Field Robotics, 25(9):569-597.
[5] Moore, Gordon E. (1965-04-19). "Cramming more components onto integrated circuits". Electronics.
[6] Major Kenneth Rose. (2002-04-12). "Robot soldiers". BBC News.
[7] Office of the Secretary of Defense (OSD), 2005. Unmanned aircraft systems roadmap, 2005-2030. Department of Defense.
[8] Patrick Lin, Keith Abney, George Bekey, 2009. "Robots in War: Issues of Risk and Ethics".
[9] Shapiro, Stuart C. (1992), "Artificial Intelligence", in Stuart C. Shapiro (ed.), Encyclopaedia of Artificial Intelligence, 2^{nd} edition (New York: John Wiley & Sons): 54-57. 4 December 2016.
[10] Sutton, R.S., Barto, A.G., 1998. Reinforcement Learning: An Introduction. Volume 1. MIT Press, Cambridge.
[11] Szabo B. and Actis R. (2011-10-19) Simulation governance: New technical requirements for software tools in computational solid mechanics International Workshop on Verification and Validation in Computational Science University of Notre Dame 17.

