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INTEGRATING MACHINE LEARNING IN MILITARY INTELLIGENCE PROCESS: STUDY OF FUTURISTIC APPROACHES TOWARDS HUMAN-MACHINE COLLABORATION

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Abstract: Automation of Military Intelligence (MI) through Artificial Intelligence (AI) has broaden the spectrum of information collection procedure and analysis function in many folds. In today's digitized world, data is produced in exponential way by every minute. Intelligence agencies around the world are experiencing new dimensions of the information what used to be overlooked due to limitation of human capacity to handle such large data set. Emergence of AI with Machine Learning (ML) as one of its subsets has brought a revolutionary approach to collect the surge of information and analyzing with numerous ML algorithm to produce various intelligence summary for strategic, operational and tactical leaders both in peace and war time. To deal with the traditional and non-traditional threat, ML based MI data collection and analysis are carried out through supervised, unsupervised, reinforcement and deep learning approaches where degree of automation is decided through human-in-the loop and human-out-of-the loop method. These ML tools will help developing system framework which will be able to sense and respond to the operational environment through adaptive learning technique so as to learn from its experience, adapt with the changing environment based on previous learning and experience. Incorporation of smart security sensors, surveillance unmanned aerial vehicle, earth observation satellites, electronic and virtual source monitoring system can augment the information collection system of MI organizations. Data analysis and data fusion can be carried out by regression, classification, time series analysis, cluster analysis, topic modeling, collaborative filtering and association rules within the framework of 4-Tiers of framework as Collection Sources, Storage & Processing, Fusion & Profiling and Data Sharing augmented by military cloud network and Internet of Things (IoT). Collaborative approach with the other Armed Forces Services, concerned Ministries, Engineering Universities and commercial Stake Holders will help formulating future policy guidelines, research & development,

ML algorithm development program and production of compatible hardwires for various ML based MI platform and applications.

Keywords: *Military Intelligence (MI); Artificial Intelligence (AI); Machine Learning (ML)*

INTRODUCTION

Military Intelligence (MI) is the process of collection, interpretation and dissemination of information to Military Commanders to assist in their decision making process. It studies the broad operational environment, analyze various actors, synchronizing relevant information and monitors ongoing events both in peace and wartime. With the advancement of technology, the spectrum of data band from various sources have been increasing in many fold and in multi-dimensions. The data is generating from strategic, operational and tactical tiers encompassing people from political, military, economic, social, business, media and many more background occupation. The intelligence analysts often face the complex task of making appropriate conclusions from this mass of information. The hypothesis drawn out of available data cannot be claimed as conclusive as it cannot be validated through maximum collected information sources. As the generated information is dynamic in nature over time and space with the evolving nature of changes of situation at a rapid pace; a conclusion drawn out of a set of information may often need validation which sometimes even ruled out in the given context due to limitation of handling such massive volume of data and information. Moreover, the authenticity of the sources need to be checked out regularly through various correlation analysis with other sources which has clear impact on the hypothesis drawn out of such information.

Undeniably, there are vast area for improvement in case of collection, analysis and correlation assessment of information due to extreme data generation spree from various sources. Use of Artificial Intelligence (AI) and Machine Learning (ML) in the collection and analysis process can be the futuristic approach. Many technologically advanced counties are transforming their intelligence system by ML using AI. Therefore, it needs to be assessed and evaluated whether ML can be adopted in the collection of intelligence information and subsequent analysis so that it can harmonize the massive flow of data both in peace and wartime to get the most accurate conclusive picture of battlefield environment and contemporary global situation.

MI is a dynamic process as due to ubiquitous activities of various actors of interest who generate a continuous flow of data. The 360^0 assessment and analysis of data, dissemination of data to concerned stakeholders, conduct of appropriate action and monitoring corresponding impact are the inseparable procedures which can

be conducted through automation driven by ML system. Moreover, functioning of Command, Control, Communication, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR) system can be boosted and operated more efficiently through ML system where the integrated system can learn from the environment and propose assessment based on iterative learning process from human operator. Therefore, integration of military intelligence, reconnaissance and surveillance can be brought under an integrated command functional system where use of AI through ML can broaden the horizon of military outlook.

CONCEPTUALIZING THE MACHINE LEARNING MODELS FOR MILITARY INTELLIGENCE PROCESS

Shu-Hsien, et al., (*2003*) highlighted a knowledge based architecture for future military intelligence planning system. A number of system architecture and system configuration have been discussed with application of ML in the form of subset of AI where a transition of automated and semi-automated analysis methods are presented. Moreover, a typical model with hypothetical system implementation strategy has been discussed.

Prelipcien, et al., (*2010*) have highlighted various AI algorithms which can be used for analysis and decision behavior model. A brief description is carried out for neural network application, generic algorithms, fuzzy logic and expert system. A set of suggested model describes that neural network can be used for pattern recognition but lacks in decision making application. Generic algorithm can be widely used for developing variety of decision options which has self-learning principle of dynamic adaptability with the environment. Fuzzy logic has been recommended for decision rules based on relationship between input and desired output. It assists in manoeuver planning and force allocation but lacks specific judgment decision. Expert system is based on knowledge based rules identifying and determining timing of action in particular situation. The discussions have been focused on application of ML as designed by various algorithm model.

Dijk, (*2019*) in his conference preceding on AI and ML in Defense Applications compiled a number of ML model for MI analysis methods. The methods pertinent to fulfill the research objectives are unmanned sensors and systems, acoustic detection of UAVs using ML methods, situation awareness through unmanned aerial system, video surveillance in the visible and thermal spectral range, neural network for visual recognition, deep learning for behavior recognition in surveillance application, deep neural network model for hazard classification, information extraction and semantic world modelling and object based multi spectral image fusion method using deep learning are proposed for military intelligence analysis.

Ahmed, (*2019*) highlighted relative importance of AI application in surveillance field for Bangladesh (BD) Armed Forces. Among various development plan of

AI subsets, it was found that ML and Deep learning (DL) would be the initial subset through which BD Armed Forces can propel through AI atomization. An AI implementation road map architecture has been elaborated which can be used as initial startup reference for exploring the desired objectives of the study. The survey responses has been used for understanding the opinion and guidelines to implement ML under various AI subsets for MI analysis framework.

Mitchell, et al., (*2019*) have discussed interlink between elements of the intelligence cycle and enumerated how ML can be applied as the subset of AI in various stages of intelligence cycle. The potential work time available to all intelligence agents due to adoption of automation through AI has provided a deep insight about the extent of acceleration of agent's efficiency in quantitative value. This has provided a quantitative comparison on efficiency of an intelligent agent while applying ML in intelligence process.

The State Council of China (*2017*) highlighted the potential general technologies, support platforms and future AI industries in order to develop intelligent computation technology to be used in future AI driven major science and technology projects. It is important to find that the knowledge computing technology is built on adaptive ML with analytical reasoning technology. Among these, key swarm intelligence technology, cross medium analytical reasoning technology knowledge computing & service technology, architecture for hybrid and enhanced intelligence, intelligent autonomous unmanned systems, intelligent virtual reality technology, intelligent computing chips & systems and natural language processing technology have been the key focus of innovation for exploring the future military intelligence analysis. Along with these, the development plan of academic research on big data intelligence theory, cross-media sensing theory, hybrid and enhanced intelligence theory, swarm intelligence theory, autonomous coordination and control, optimized decision-making theory, high level ML theory, brain inspired intelligence computing theory, swarm intelligence theory and quantum intelligent computing theory have been projected as guiding academic discourse on ML application for intelligence analysis. These will build knowledge-based architecture for future military intelligence analysis through ML. These are essential academic guidelines where continuous development would create Research & Development program for ML for military intelligence analysis. Together with this theoretical framework, Haridas (*2015*) has put forward Big Data analytics which is utilized for intelligence gathering for national and military intelligence where big data analytics based intelligence can provide requisite output for decision making. ML is used as a tool in big data analytics in a neuro-network of intelligence data collection framework by which threat alert system, social media monitoring, information mining, document analytics and cyber security can be carried out. A conceptual layout of big data application based intelligence gathering system is discussed where real time advanced analytics on various information data from multiple collection sources can be carried out to provide situational awareness, decision making and

battle assessment. These have given a detail theoretical concepts on which research & development of ML can be carried out in future.

Michael O'Hanlon *(2019)* forecasted an eminent change in military technology in next 20 years where he focused on future trend of military technology. Among four categories of breakthrough of technology, the first is sensors which gather data of relevance of military operations and the second is computer & communication system that process and distribute that data. A projected advances in key deployable technologies 2020-2040 is predicted where probability of deployment of sensors and other communication system are shown. It provides a clear projection about future development of intelligence collection sources, communication and information processing technology. Connable *(2012)* highlighted the fusion process of various forms and format of intelligence data and presented how the fusion process is essential for future complex environmental analysis of relevant national and international actors. A System-of-Systems analytic map encompassing political, economic, military, social, and informational infrastructure explains how the 360º information flow is affecting both strategic and operational center of gravity which validates the disruptive transformation of future intelligence data collection and processing spree. It depicts how fused intelligence picture reflects better ground picture thus helps intelligence agents to understand the complex socio-politico-military environment and produce interlink with the big picture. Thus a paradigm shift is sought in regards of intelligence data fusion analysis for future complex operational and strategic scenario.

To conduct the fusion of data from various sources, Cruickshank *(2019)* proposed to develop the ability of MI structures to distill knowledge from raw data through application of Data science. It is proposed that using ML and other AI techniques, Data science would be the preferred discipline for analyzing both structured and unstructured data from various collection sources. In this regard, Kendrick *(2019)* showed a framework of adopting Data-Centric Culture at all Army echelons. This allows an institutional approach to integrate data science effectively into Army intelligence at every tier of Army decision and execution level. The Data science tools can automate the complex steps of intelligence process which ultimately develop the MI database. These concepts can provide to develop suitable ML models for military intelligence process.

Dopico, *et al.*, *(2009)* in their "Encyclopedia of Artificial Intelligence" compiled a large number of research articles on present development of AI technology. Among the articles, various latest intelligent system modelling, adaptive technology, artificial neural network, AI for information retrieval, cognitive modelling, behavior based clustering of neural networks, decision making in intelligent agents, facial expression recognition program, hierarchical reinforcement learning, natural language processing program, supervised learning by fuzzy logic system and swarm intelligence approach model can provide a start-up framework that can be used to explain how ML can be used in interpretation

of intelligence data and transform those to usable information. There are ML program development guidelines which can be of immense importance for research & development program for ML system for MI analysis.

GLOBAL MILITARY MACHINE LEARNING APPLICATION FOR MILITARY INTELLIGENCE ANALYSIS AND VARIOUS MACHINE LEARNING MODELS

ML, a subset of AI has been used extensively by militaries of developed and developing nations in their various military application and war fighting platforms. ML is a subset of AI where algorithm language is used to analyze and learn from data (*Bhatnagar, 2018*). ML seeks to learn and adapt its pattern of thinking by analyzing meaningful relationship and pattern of data from examples and information which is designed to work in a similar nature of human cognitive logic (*Janiesch & Heinrich, 2021*). Use of AI as the key technologies to fight and win the war in future has been taken as future strategy by United States (US) declared by US National Defense Strategy in 2018 (*Defense, 2018*). Russia reiterated in 2017 to pursue AI technology as the President of Russia publicly announced its stance for its future military outlook (Simonite, 2017). China has released a strategy in 2017 detailing a roadmap to lead military technology through AI by 2030 (*Council, 2017*). Project Maven is one of the leading ongoing military AI implementation project where Pentagon started military use of ML by converting drone video into actionable intelligence through Algorithmic Warfare Cross Functional Team in its campaign against ISIS in Iraq and Syria (*WEISGERBER, 2017*).

System Architecture for MI Process

MI process integrates intelligence, surveillance and reconnaissance (ISR) which develops the intelligence circulation (IC) process. Generally, it incorporates spatial database, attribute database, case base, rule base and a knowledge repository through which MI process works. Military reconnaissance is the process of acquiring information about hostile forces and terrain of own operational interest. Military surveillance is the monitoring of activity based on reconnaissance data in order to remain updated current situation of interest. MI incorporates the process of analyzing the reconnaissance and surveillance data and transforming the raw information to usable intelligence of military interest for current and future operations (*Liao, et al., 2003*). The framework of military ISR is shown in Figure 1.

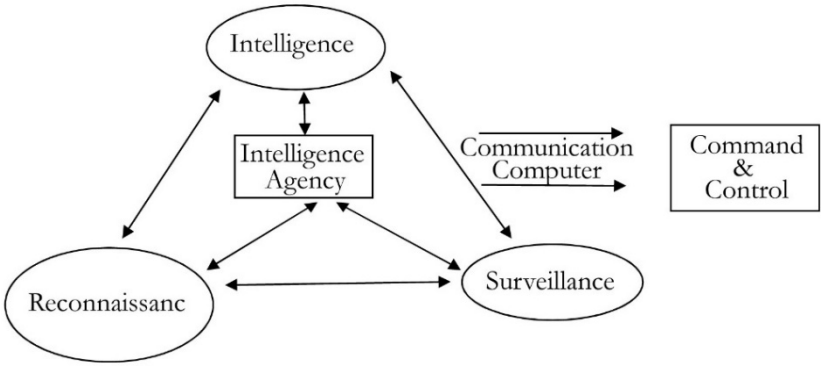

Figure 1: *Framework of Military ISR (Liao, et al., 2003)*

The intertwined process of MI as evident from figure 1 enumerates that each process complements others and lack of activity in any of the process will bring down the entire IC process. The continuous coordination, revision, update and execution can be accelerated through automation with least error probability. Therefore, latest inclusion of reinforcement learning method of AI facilities the entire process through human-machine collaboration in the intelligence analysis framework.

The MI process has been carried out by using management information system (MIS) through which explicit knowledge is processed. But in today's world, there are huge volume of big data generating encompassing physical and virtual data. There are various kinds of databases such as attribute database, spatial database, case base and knowledge repository. Geographic information system (GIS) and knowledge based decision support system (KBDSS) are being used to integrate the function of decision support and knowledge management to enhance both explicit and tacit knowledge base. In this aspect, it was proposed to incorporate intelligent operation support system (IOSS) structure through which rich knowledge representation is done by hybrid reasoning strategy which proved its applicability in production decision system *(Xia & Rao, 1999)*. The system is operated based on learning from documented knowledge, learning from problem solving, and situational learning from problem solving failure and learning from forgetting. This is called adaptive and reinforcement learning that is the main attribute of ML and core function of AI. Due to dynamic nature of intelligence collection, accumulation, analysis and dissemination functions, reinforcement learning based ML functions is becoming more popular and depending approach towards MI process.

Hierarchy and Configuration of MI Process

Hierarchy and configuration of MI is broadly divided into three levels *(Liao, et al., 2003)*. The first level consists of operational and tactical intelligence collection

organizations and units. These are employed to collect data, pictures, signal and cyber information through reconnaissance and surveillance operation. These operations are broadly sub-divided into human intelligence, signal intelligence, image intelligence and communication intelligence. The second level conducts different intelligence analysis of the data and information provided by the collection organization and units. At this level, both routine and special intelligence report is provided based on day-to-day and emergency requirement respectively. The archiving of routine intelligence is one of the essential part at this level which is updated regularly and retrieved in terms of necessity. The third level is the user organization, higher headquarters and senior leadership who often place the requirement of intelligence. They are also provided with regular update of situation awareness and special circumstances of operational and tactical value.

The operational process of MI is divided into regular and special mission. In regular mission, operational attention is focused on basic intelligence collection based on routine and standard operating procedures. The special mission which is often time bound, focuses on acquiring specific intelligence from particular event, situation and persons. Both of these operational process thus develop IC which is shown in Figure 2.

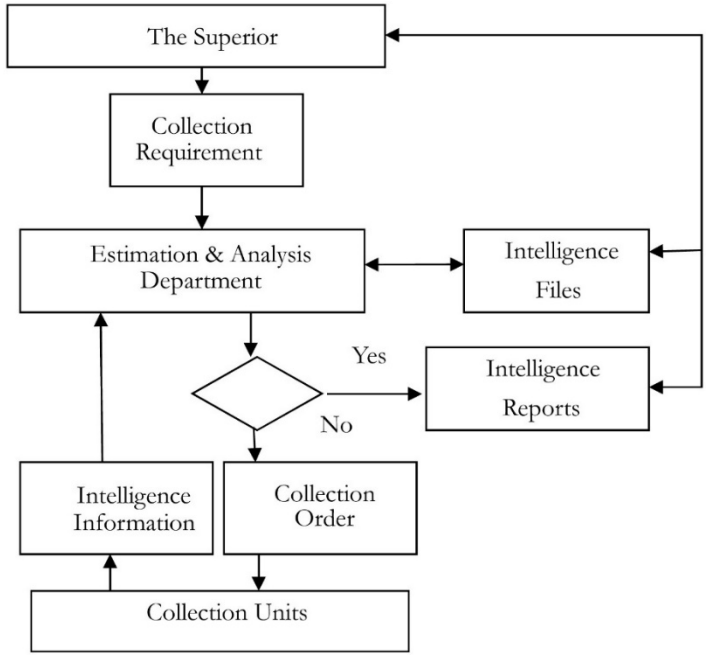

***Figure 2**: Military Intelligence Operation Process (Liao, et al., 2003)*

The generalized intelligence operational process is built on the processing of raw data collected in the first level of MI collection organizations and units. The

process of converting raw data into information is done by tacit and explicit knowledge base. There are core differences between these two types of knowledge base. Tacit knowledge is the accumulation of experiences, logical thinking and guts feeling of any intelligence agents which is more of personal attributes in nature (*Oliver, et al., 1997*). It varies within persons and the decision out of such knowledge base is often unexpected and may not be based on logical reasoning (*Hedlund, 1994*). Though there are instances where tacit knowledge proved to be the reasonably the correct way to predict any outcome based on intelligence findings. On the other hand, a set of rules, methods and techniques based on doctrinal fundamentals are explicit knowledge which is more precise, articulated and structured in nature (*Zhang & Griffith, 1997*). In addition, procedural knowledge is the standard operating procedure supported by explicit knowledge (*Anderson, 1985*).

Why ML is the Disrupting Technology for MI Analysis

In today's digitized world, the humans are floating in the abundance of data which are increasing in an exponential way. The variety, volume, velocity, vector and ubiquity of data are not only disrupting today's operational outlook but also endangering national security by overlooking the interpretation of the information carried through it. Under the adage of "Information is Power", the Security Forces must possess the capacity to interpret such constantly increasing structured and unstructured data and find pattern to help facilitating developing intelligence database for both peace and war time. The Intelligence Agencies around the world are reorienting and restructuring their traditional method of intelligence operation to accommodate the dynamic flow of data and preparing to analyze large data sets. It is evident that sustaining in the future technological era, intelligence outlook has to be broaden and dependent on amassing and organizing most of the data of own operational interest to visualize the future scenario.

Generally intelligence operation consists of five interconnected and interdependent cycle. These are Planning, Collection, Processing, Analysis and Dissemination (PCPAD). The Collection, Processing and Analysis (CPA) stages are crucial and need attention from technological aspect as the sheer volume of handing and processing have already exceeded the human capacity. The types of collection sources ranges from sensors, aerial system, satellites, radio signals, open source internet, social network, different organizations, agents, adversaries and many more. These data comes in different format in varying time and space in different medium either in the digital format as binary data or written & oral data. Thus, it needs a universal interpretation system where all types of format of data can be handled, stored, interpreted and common intelligence pictures can be made.

Having submerged in the flow of data according to Desjardins (*Desjardins, 2019*), the tech -savvy world is producing surges of data which is shown in Figure 3.

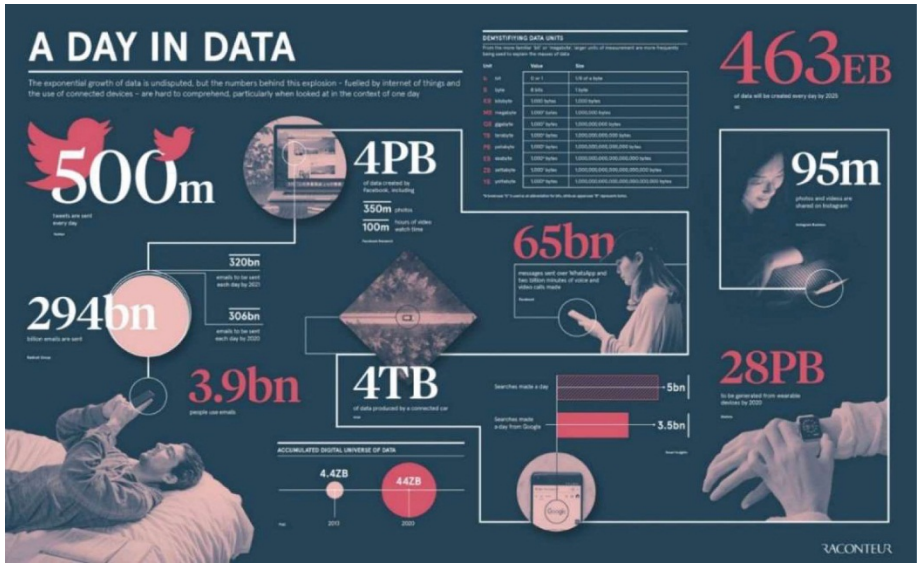

***Figure 3**: A Day in Data in 2019 (Desjardins, 2019)*

Bulao (*Bulao, 2020*) has summarized the following details about how much data is being generated in the world through information highways in internet world.

***Table 1**: Data Generation through Information Highway (Bulao, 2020)*

Volume of Data	By	By Time	Year
1.7 MB bytes	Each person	Each second	2020
2.5 Quintitrillion bytes	"	Every day	2020
463 Exabytes	"	"	2025
95 Million photo in	Instagram	"	2020
306.4 Billion	Email users	"	2020
5 Million Tweets	Tweets users	"	2020
3.5 Billion search	Google search engine	"	2020
350 Million photos in Facebook	Facebook users	"	2020
4 Petabytes	Facebook users	"	2020
500 hours of video	You Tube	"	2020
32 Billion IoT devices	Each person	Each second	2020

These are the glimpses of data volume and data type which will need to be analyzed for preparing intelligence database in peace time so that it assists in extracting essential element of information in need of time. Moreover, Non-

Traditional Security (NTS) threat remained high throughout the last decade and it has already appeared as new security concern. Therefore, intelligence against NTS threat need to be developed, updated and monitored each day to remain abreast of any impending situation due to the unpredictable behavior of actors. In war time, under active battlefield scenario, continuous reconnaissance and surveillance are essential and integral part of any operational activities. In battlefield environment, these data from various sources are added to the previous digital database, hence producing massive flow of data which is impossible to handle and organize by human operator using traditional collection, storage and analysis methods. In the ongoing technological era of AI, supervised and unsupervised ML is used extensively to collect massive volumes of data. The advantages of using ML is that it can train itself autonomously or semi-autonomously to arrange data that is needed for MI purposes which enables it to label the data with usable pattern. Therefore, ML system can easily sifts through billions of bytes of data and captures the needed types of data to create meaningful information for MI. While ML is applied in collection of data, the system prepares the data by correct identification, locating, profiling, sourcing, integrating, cleansing and storing through data mining (*Chan, 2020*).

Global Military Application of ML in MI

Having discussed the broad structure of MI process and system architecture, militaries of different countries have been developing and reorienting their MI process through supervised learning and reinforcement learning AI subsets by focusing on tacit and explicit knowledge respectively. Following this, an exhaustive restructuring has been carried out over various ongoing MI process systems which will have their dominance over next foreseeable future in the formulation of MI process. A few recent development of automated system for collection and analysis of MI process has been discussed briefly.

- Multi-Domain Command and Control System (MDC2) is one of the centralized platform to collect and analyze raw data collected from land, air, sea and cyber spaces through sensors and sources. These fusing of data to the central system is done to create a single information base thus creating a common operating picture for the decision makers *(CLARK, 2017)*.
- Border Surveillance System (BSS) has been developed to carry out automated surveillance on the objects and personnel along the borders. It consists of sensors, network sources and databases where the algorithm is developed to calculate the indicators which gives predictive values for the threat. It can not only estimate the level of threat but also can assess the level of uncertainty of a series of events. Bayesian Reasoning, Endorsement Theory, Fuzzy Reasoning, and Dempster Shafer Theory are used for the design of the BSS along with the programming algorithm (*Albertus C. van den Broek, 2019*)

- Acoustic Detector which operates through ML methods is an active detection system which can track and detect small miniature objects in the air and ground. ML approach is used to detect and evaluate multiple algorithms' performance using real time data as fed from various sensors and radars. This can differentiate various audio signature from audible and non-audible spectrum. The ML based detection algorithms can sift through noise deduction and produce actionable intelligence through operating environment (*Alexander Borghgraef, 2019*)
- Video surveillance in the visible and thermal spectral range through augmentation techniques employs deep neural network to record and detect texture and thermal images. The convolutional neural networks is designed under adaptive learning algorithm by taking sensor data from various sources and make decisions. It is particularly useful in large-scale multispectral Thermal World dataset in the long-wave infrared and visible spectral range (*Vanessa Buhrmester, 2019*).
- Deep learning for behavior recognition in surveillance applications has been using ML to automate the sensor data analysis in surveillance systems. The system works on the recognition of the behavior anomalies between persons and tracking persons with specific behavioral pattern (*Maria Andersson, 2019*). The system works on analyzing different behavioral characteristics with the preset behavioral patterns of people with people, people with object and people in particular places of interest. This is designed on supervised learning model where different behavioral category and patterns are installed with which subject behavioral characteristics are analyzed and examined to sift and detect required people of interest.
- Information extraction through Semantic World Modelling is developed for finished intelligence by combining and analyzing different intelligence input. These intelligence input are in the form of Human intelligence (HUMINT), Imagery intelligence (IMINT), Open source intelligence (OMINT), Virtual source intelligence (VIRINT) etc. The integration, processing, fusion and consolidation of information produce a common intelligence using data driven ML mechanism and a semantic world modelling is produced. These are developed for structured and non-structured data with deep learning methods *(Almuth Hoffmann, 2019*).

ML Algorithm Development Models for MI Analysis

There are efforts and development taken in the field of application of ML in the sector of defense, economy, healthcare, transportation, aviation, space technology, business and many more. It is interesting to find that the combined efforts can accelerate the development of defense application. For MI, many of these ML algorithm can be useful in exploring the application in future which have been under either theoretical study or already in industrial application.

Following some of the relevant ML, algorithm models have been discussed with their future scopes of applicability in MI analysis.

- Retrieval of multimedia information from internet sources and communication medium generate large volume of data in a high dimensional space. Active Learning Support Vector Machine (ALVSM) has been developing to deal with such high dimensional system and thus can act as an essential system for MI data collection and analysis *(Jiang & Horace, 2009)*.
- Agent Based Intelligent System Modelling is developed to sense and respond to the operation environment as an adaptive system to acquire and store information, learn from its experience, adapt with the changing environment based on previous learning and experiences and pre-determined objectives with revised direction with automaton or semi-automation control. The rules are continuously revised through adaptive learning which make the system appropriately encounter in the changing and evolving circumstances and make necessary decision output. The intelligent agent works on the principle of monitoring, listening and responding through agent-based modelling (ABM) with incorporation of human and machine-based data *(Tang, et al., 2009)*.
- Ambient Intelligence (AmI) seamlessly integrates smart devices and infrastructures through Internet of Thing (IoT). It integrates all the collection and surveillance sensors, intelligence system, human, computer and social interaction by speech recognition and image conversion. The system works through intuitive interfaces by cognitive reasoning and delivers suitable options to the agents *(Sadri & Stathis, 2009)*.
- Facial Expression Recognition System (FERS) works in cognition of human emotions and captures facial expression in a number of image sequences. Human-Machine interaction interprets the facial movement and analyze the emotional state *(Dornaika & Raducanu, 2009)*.
- Data mining and data warehousing are widely used to manage and analyze large datasets through pattern recognition technologies. Data warehousing can be used to store data which can be retrieved in time of need. Data mining is used to compress the huge repositories of information. It is a multi-disciplinary field covering large data sets, pattern recognition, ML, information & control theory, information retrieval, parallel & distributed computing and data visualization *(Zhou, 2003)*. The most pertinent data mining activities for MI analysis could be associations, sequences, classification, clusters and forecasting through neural networks, decision trees, regression analysis and memory based reasoning *(Wang, et al., 2009)*.
- Geographical Information System (GIS) with sensors, AI and ML produce digital mapping where inputs are taken from ground based

sensors, aerial platforms and satellites. It produces customized portable maps with updated objects placed in real time and space along with accurate geographical coordinates for detecting and tracking system. The image and object processing is done by deep mining modeling through adaptive and supervised ML (*Matheson, 2020*).

- Sensors based Cognitive Platform works through various data and image collection sensors in a wide neural network system. The platform is operated through Fuzzy logic and Genetic algorithms and form both Expert and learning system (*Hamblem, 2017*).

POTENTIALS OF MACHINE LEARNING FOR MILITARY INTELLIGENCE

To develop complete intelligence summary under the big picture, the need to correlate and fuse all intelligence data from multiple collection sources is obvious. There can be three categories of tools based on ML approaches such as supervised learning, unsupervised learning, reinforcement learning and deep learning. Alkire (*Alkire, et al., 2016*) categorized the analysis tool as Enable analysis, Perform analysis and Support analysis. Enable analysis tool under supervised learning approach helps intelligence agents to perform specific analytic tasks quickly, accurately and completely. This semi-automated tool performs the analysis task with human- machine interaction with human-in-the-loop structure. Perform analysis is a fully automated tool replacing intelligent agents; thereby operates under unsupervised learning approach with human-out-of-the-loop structure. The perform analysis tool can operate through task based and cycle based. Task based tool offload specified task from intelligence agents and complete the task autonomously. Cycle based tool perform all the steps of intelligence cycle completely without human intervention. Support analysis tool under reinforcement learning and deep learning operates through adaptive learning where it supports the intelligence agents by knowledge management databases, modeling, simulation environment, inter-personal collaboration, vertical and horizontal collaboration.

The synthesis of data is an essential step of intelligence data analysis. Its purpose is to combine all the disparate elements together as derived from various collection sources for developing intelligence summary of a single event and situation. This synthesis is carried generally in three levels. The primary level is basic analysis and exploitation where data from single source is summarized to make an intelligence product. This is the critical foundation level as the chain of synthesis to next level depends on this data combining stage. The advanced analysis and exploitation level interprets data from multiple sources where the analysis and exploitation become more complicated due to volume and types of data from multiple sources. Parallel to this level multisource analysis and multi-intelligence fusion can be created to find relationship between intelligence

products which can be considered a deeper stage. This is done mainly to find out data pattern so that forecasting of probability of any intelligence event can be predicted beforehand. The last level is all the source analysis where all available data are fused and synthesized together and a more accurate prediction of a target is done in regard to time, place and behavior. This type of analysis need a holistic approach towards combining all types of data format which can best be done by supervised learning ML approach.

Human-machine interface and human-machine collaboration are important phases of incorporation of ML in MI. Human-in-the-loop system has been preferred in the degree of autonomy of MI process. Incorporation of ML in MI process can be developed through a number of tiers. These tiers are interlinked and interconnected that can be placed from the headquarters to field units to facilitate flow of information from various sources.

Tier 1 (Collection Sources)

Tier 1 will primarily consist of human, mechanical and electronic sources. Sensors, drones, satellites and radars can be placed to collect image sources round the clock from all over the country and in the area of interest for operational purpose. Sensors are static devices, low cost device that can be readily placed in places of interest. There can be local area connection established between the sensors where the image data can be collected in local database maintained in the decentralized servers across the country. This data storage function will be coordinated in Tier 2 (Storage & Processing) where the storage of all the image data from the sensors can be collected, sorted and sifted in a central database. Drones and satellites are tactical and strategic assets respectively that can detect, track and locate stationary and moving objects. Drones can send the image data to both local and central database whereas satellite's data can be sent to central database. As satellites range extends beyond border of country, it may have a separate database for external image storage. Radars are static detection system which can detect flying objects, moving objects and terrain configurations. These image data can be stored directly to central database by optical fiber network.

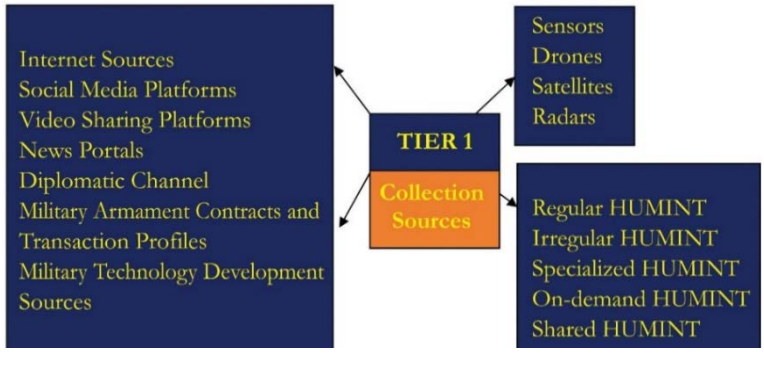

Figure 4: Tier 1 (Collection Sources)

Functions of Smart Security Sensors, Unmanned Arial Vehicle (UAV), Earth Observation Satellites (EOS) and Electronic and Virtual Source

Peace time surveillance is one of the major functions of MI department. For such purpose, besides manual and human collection of information, sensors, UAVs and EOS can play a dramatic role in collecting large volumes of data and information.

- **Smart Security Sensors**

Smart security sensors can build the critical element of MI collection system. These are static and inter connected sensors through Internet of Things (IoT) which can form a large surveillance network system across the border of the country. These can perform a wide variety of functions ranging from environmental monitoring, weapon control, communication & signal interception, monitoring military movements, crime detection, intrusion detection, NBC detection etc. There are various types of sensors which can be utilized for MI purpose based on their system of work and application techniques. Active sensors functions through own sources of radiation which operates in microwave and radio wavelength regions in electromagnetic spectrum. It supports various ML algorithm covering movement detection and intrusion detection. These are associated with radio signal processing from intricate noise spectrum through automated extraction process under ML algorithm. Smart and intelligent sensors functions through reinforcement learning mechanism which are multifunctional, self – diagnosed and self – compensated device. These are built with high resolution image sensing processors with higher processing chips which can rapidly transfer and share data from remote stations to central or local hub of database. Short wave image radiation mechanism has proven it as one of the sophisticated and reliable sensors for MI purpose. Micro Electro Mechanical System (MEMS) sensors functions through electro-mechanical sensors which are miniaturized in size and are very popular for its rapid deployment at short notice. These are ideal sensors in rough terrain and environment with prolonged duration of operation. The visual interpretation data generation process makes it one of the trusted detection sensors for military. Nano sensors work with Nano-technology and regarded as the state-of-the-art technology for MI purposes. These are durable, strong, light weight and works through adaptive learning algorithm. These emerging technology shares data through creating local virtual cloud network. These provide better connectivity in an inaccessible terrain configurations which works through cognitive learning methods with projection through augmented reality (AR) interface (*Electronicsforu, 2018*).

- **Surveillance Unmanned Aerial Vehicle (UAV)**

Surveillance Unmanned Aerial Vehicle (UAV) serves as one of the essential systems to gather image and video data of terrain which are inaccessible and vulnerable. Moving Object Detection and Tracking (MODAT) framework modelled by high resolution computer vision and image processing techniques are used to create geo-spatial map and other image documents. The monitoring of the terrain objects, tracking of the moving objects and updating of real time position data facilitate 24-hour surveillance of the area of interest. These are independently operated, adopted in cluster and communicated in decentralized method to ensure optimum security and application flexibility. The automated MODAT framework operates under three modules such as image alignment, motion detection and object tracking module. The large computation of the image data is carried out through various image processing algorithm with reinforcement learning AI subset (*Ibrahim, et al., 2010*).

- **Earth Observation Satellite**

Earth Observation Satellite (EOS) is an invaluable intelligence collection system covering wide area of terrain thereby perform as strategic asset of any military. EOS can observe the terrain where the satellite images at different elevation are taken and sent back to central control station. After due processing, these images can be studied through ML about change of pattern of terrain configuration and provide alert about the potential intrusion across the border. The entire process of image capture, storage, processing and interpretation of the images with the current and previous setting are done autonomously by various AI subsets.

- **Electronic and Virtual Sources**

Apart from other traditional and existing intelligence sources, electronic and virtual sources are of utmost importance for MI. The digital signature and potential information appear in various electronic media and virtual information highway (Internet, social media networks and other media sources), can build a 360º perspective and assessment about any impending situation. Reinforcement of AI learning through supervised algorithm modelling framework can extract the required information from these medium. There is need for constant supervision by human agents which can be achieved by supervised learning program. The electronic sources over internet are one of the major information sources where ML would perform a significant role in detecting and extracting required information. It can sort and collect required information with self-automation process which is often overlooked by intelligence agents due to abundant volume of data. The sources of potential intelligence range from internet web sites, social media

platforms (Facebook, Twitter, Instagram etc), video sharing platform (YouTube, Vimeo, TikTok etc), news portal (national and international), media channel (national and international). The data from these sources often comes in unstructured image and voice data format. Diplomatic offices are one of the authentic sources that provides recent development of allied countries in respect to political, economic and military development which often comes in structured format. Global Military armament contract and transaction details can provide latest armament capabilities of potential adversaries. These are mainly structured data and the collection sources are often needed to be verified in Tier 2. Along with this, various military technology development programs can be sources of utmost importance to have an understanding of future development trend in military. These data are in structured format and often need verification in Tier 2.

- **Human Intelligence**

Human sources will remain the most important source of information as in vogue for BD Army. HUMINT can be collected through a variety of human and other sources. These can be categorized as Regular, Irregular, Specialized, On-Demand and Shared HUMINT. Regular HUMINT are collected from general collection sources which are trained and placed under regular employment principles. Irregular HUMINT are collected from the sources which needs verification regularly. These kind of sources must qualify the validation parameter set in Tier 3 under personality profile. Specialized HUMINT is collected from the highly classified sources which are often placed in hibernation state in places of interest that collects information based on self-actuation mechanism. The specialized sources are usually verified before placement but needs to match the pattern of activities which is carried out in Tier 3. On-Demand HUMINT are the extension of regular HUMINT where sources are often placed in certain circumstances for specific time frame. Shared HUMINT is the common intelligence often received from other organizations either on-demand or for common purpose. The mode of HUMINT comes in the form of written, oral and encoded format of data. This structured, semi-structured and even unstructured data can be analyzed through data mining, NLP and text analytics. Unstructured Information Management Architecture (UIMA) frame can be used in Tier 2 to process semi-structured and unstructured data and create a common structured database.

Tier 2 (Storage & Processing)

In Tier 2, data storage, data processing, data flow and data processing hardware synchronization will take place. Data from various sources can be stored in decentralized server which can transfer data to central database. The on-demand

data can also be extracted through military cloud network. Data processing can be carried out through ML algorithm and AI subsets. For structured data, supervised learning system can be used with limited autonomy. For image and voice data, reinforcement learning can be used so that it can learn from the environment and adaptive configuration with situational experience can be inherited. NLP can be applied for all kinds of voice recognition, voice interpretation and voice orientation. Storage of electronic sources can be achieved through neural network within Big Data framework. Data flow can be carried out through secured fiber optic network. Moreover, the mechanical collection sources can be interconnected by IoT so that flow of data and control of devices can be performed instantaneously and centrally.

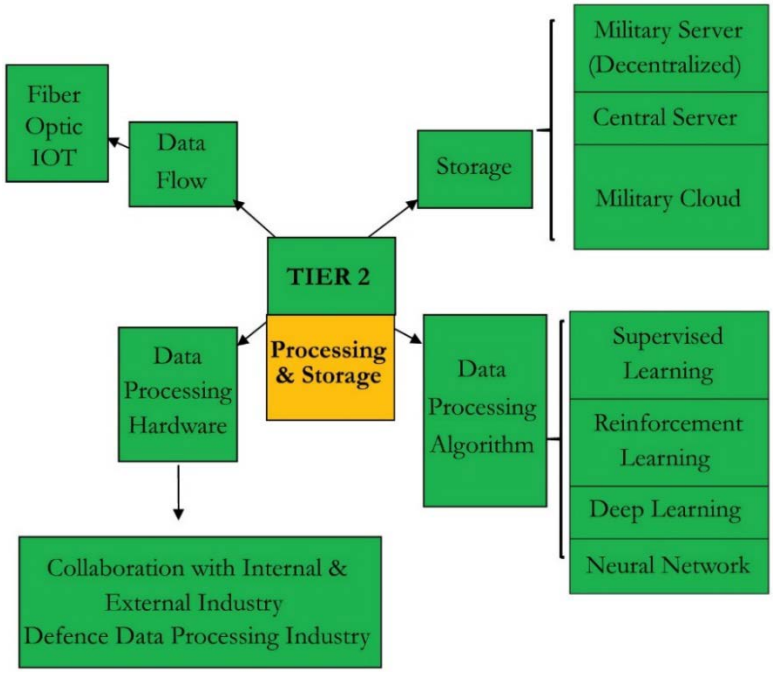

***Figure 5**: Tier 2 (Storage & Processing)*

ML Processing of Intelligence Data

The data thus derived through various collection sources will form the framework of Big Data. The ever changing landscape of data structure in the digital format needs ML based algorithm for digital data processing which is an evolutionary field of study. Data processing by ML algorithm is carried out by data selection (structured, semi-structured and unstructured), data processing, data transformation, data output and finally data storage. There are various methods of ML algorithm in the growing data science field. Among these, regression,

classification, time series analysis, topic modelling, cluster analysis, collaborative filtering, association rules and dimensionality reduction are popular and are being used widely in both military and commercial purposes (*Bhatnagar, 2018*). While using ML algorithm for data processing, there are three learning types of ML technologies that can be adopted. The three sub domains of ML which would be used extensively are supervised learning, reinforcement learning and automated/unsupervised learning. Among these sub-domains of ML, supervised learning is used for classification and estimation of the data processing tasks that use Neural Network, Bayesian Network, Naive Bayes, Support Vector Machine and Markov Model Algorithm. Reinforcement learning is used for developing decision making tasks from the intelligence data sets. Reinforcement learning uses Q-Learning, R-learning, TD learning and Sarsa learning algorithm. Unsupervised learning mainly functions for producing clustering of data for making future prediction events through trend analysis of situation. It uses k means, Gaussian model, X means and Dirichlet process model algorithm (*Bhatnagar, 2018*). There are Big Data framework for processing and analyzing the intelligence data generated from various sources. Among many, Hadoop framework for intelligence data processing would serve the best for MI analysis (*Chowdhury, n.d.*).

Tier 3 (Fusing & Profiling)

Tier 3 functions by fusing various dataset so that personality model, dynamic personality profile, decision model, dynamic situation model and integrated early warning (EW) system can be developed. Along with HUMINT; collecting, collaborating and fusing individual person's interaction in Online Social Network (OSN) and other websites in the internal dynamic personality profile of military and non-military persons of interest can be created. This selection of person may range from adversary's military and non-military leadership along with suspected actors of non-traditional threat groups. According to (*Souri, et al., 2018*), Eysenk three-factor model [Psychoticism, Extroversion, Neuroticism (PEN) model], Big Five model and Alternative Five model are widely used model to describe personality profile. For this, ML algorithms such as Naive Bayes, Decision Trees, Neural Network and Support Vector Machine are used to analyze the online datasets. The personality profile which will be updated and reframed regularly can be performed by reinforcement learning of AI subsets. Based on a number of personality profile of a person under various circumstances as per his behavior reaction, personality model is prepared. This personality model will be used extensively about developing numerous decision models which will be invaluable ingredients to strategic and operational leadership. Similarly, based on various activities under a certain situation, the combination of activity elements can be fused together in random manner to predict upcoming situation. Thus, fusing of situation elements will construct dynamic situation model using adaptive learning method of ML. All these models will help creating integrated EW about person of interest and any situation for senior leadership in particular and forces in general.

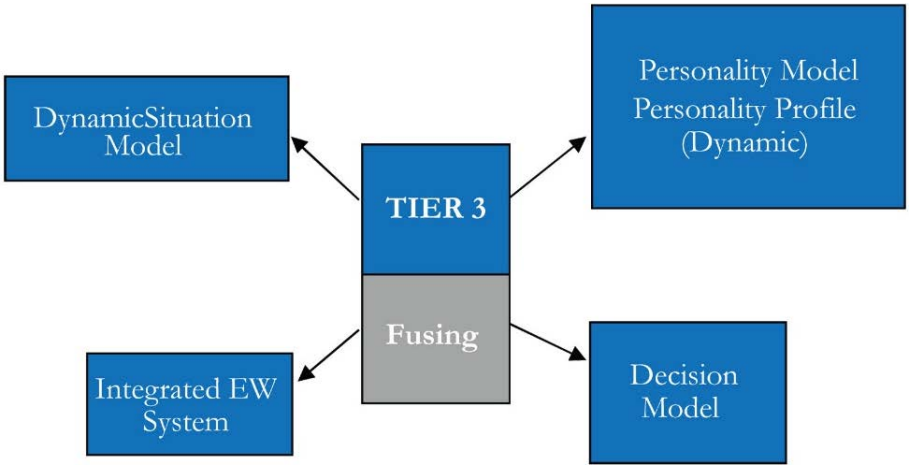

***Figure 6**: Tier 3 (Fusing & Profiling)*

Characteristics of Data Fusion of MI Information

- Data fusion is the method by ML to process all types of data into a usable format and prepare a unified picture of ongoing and future situation. ML generally conducts this data fusion through data imperfection, data correlation, data inconsistency and disparateness of data. Data fusion is the multi-level, multifaceted process handling the automatic detection, association, correlation, estimation and combination of data and information from several sources (*F.E.White, 1991*). It is the process by which information in transformed from different sources and different points in time and space. This process improves the detection capability, reliability, reduce data ambiguity and extend the spatial and temporal coverage ranging from boundary of the country to area of points of interest. JDL model is one of the most common and popular fusion system which is based on the input structural data and produce output in the military domain through four increasing levels of abstraction as object, impact, situation and process refinement. JDL model has mainly focused on input-output data more than that of processing. On the contrary, Dasarthy's framework allows both input/output data flow and functional process (*Dasarathy, 1994*). Based on uncertainties of events in global, regional and national level, often MI needs to accommodate random sets of information. It would be useful to build numerous decision model based on these random sets of data. In this regard, Goodman's (*Goodman, 1997*) random sets can be of very useful process which has the ability to combine decision

uncertainties as well as presenting generic pattern of uncertainty options.

- Data fusion technology for MI data transformation must undergo a robust adaptive programming framework that can address imperfection of data type, diversity of data type, variety of sensor technologies and nature & type of operating environment.
- Data fusion algorithm need to be capable of withstanding imperfect, imprecise, data type as collected both from fields by agents and by sensors. It should also be able to export the redundant data thereby reducing the noise in measurement.
- Data fusion system should be capable of avoiding counter intuitive results and able to treat highly conflicting data with due attention thus eliminating enhances of decision errors.
- Data fusion scheme should be able to handle both homogeneous and heterogeneous data as audio, video, radio signal and other forms of signal sources.
- Data fusion system need to overcome the calibration error induced by individual sensor modes through sensor registration as the transfer of data would take place from a common frame which collect data from individual sensor's local frame. This processing can be done both in a centralized and decentralized manner. The decentralized fusion process can be useful in remote inaccessible terrain where wireless sensor network will have to be established.
- The data fusion method should address multiple time scales to deal with multiple variation of time scale on which sensor would receive and send data. As the data flow will be through variable routes, there may be chances of out-of-sequence arrival of data. To address such potential pitfall of performance variation, the fusion center should have distributed fusion settings.
- The fusion process must be operated through reinforcement learning method so that it can accommodate changes quickly and update accordingly thus showing the dynamic phenomena.

Data Fusion Methodologies

Real time data fusion system will face numerous challenges as the methodology is yet under exploration. The main challenges comes from unstructured, incomplete and imprecise data. It is evident that MI data would never come as complete structured format as the forecasted sources range from human sensors, drones, satellites and other virtual & online platforms. Khaleghi *(Khaleghi, et al., 2011)* depicted several data related challenges in data fusion system. The taxonomy of data fusion methodologies is shown in Figure 7

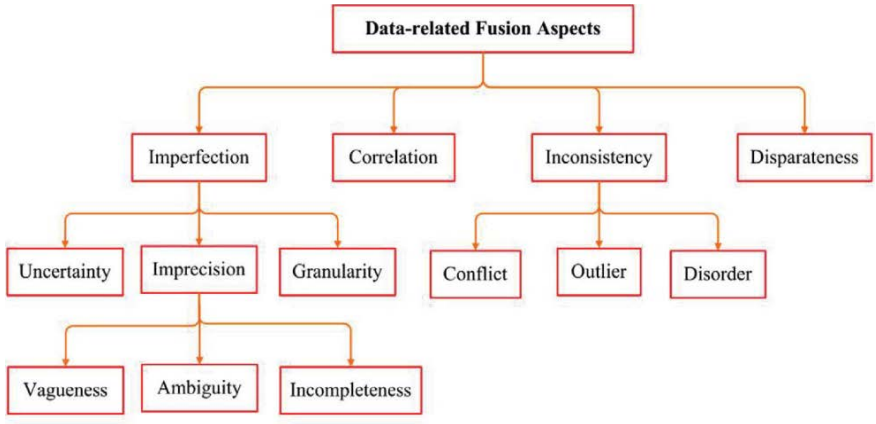

***Figure 7**: Taxonomy of Data Fusion Methodologies (Khaleghi, et al., 2011)*

Regardless of the data structure, ML can use data fusion algorithm and create data structure in a number of data model for various requirement of MI. Among these, the most fundamental challenging problem for data fusion system is data imperfection which comes in the form of uncertainty, ambiguity vagueness, incompleteness and granularity. There are numerous suggested imperfect data fusion framework to address such limitations. The popular data fusion framework is Probabilistic, Evidential, Fuzzy Reasoning, Possibilistic, Rough set theoretic, Hybridization and Random set theoretic fusion. This framework has the capabilities to treat data uncertainty, fusion of ambiguous data, handling of vague data, handling of incomplete data and fusion of imperfect data.

Tier 4 (Data Sharing)

Tier 4 is the data sharing platform where completed situation models and integrated EW will be shared with internal and external stakeholders. This centralized data sharing platform will be connected to all the formation headquarters so that situation awareness can reach instantaneously. These can be connected through fiber optic network with separate communication hub to other organizations and stakeholders.

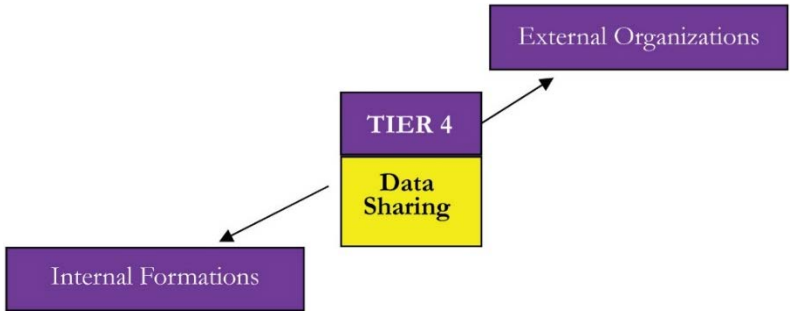

***Figure 8**: Tier 4 (Data Sharing)*

Military Cloud Computing in MI Fusion Process

Military Cloud Computing (MCC) can be a convenient on-demand shared network access for common intelligence data and resources. The vital accessibility function of MCC makes it reliable, durable and secured with military grade protection from cyber-attacks. It will offer a dynamic resource pool and storage facility for all intelligence big data and other resources so that any intelligence agent can get access to it at any time in any part of the world and at the same time can upload all kinds of data in any time. In this way, MI resources can be shared and accessible for 24 hours' time. The MCC can be constructed in 4 layers of individual decentralized functionality. Cheng & Liao (*Cheng & Liao, 2011*) named these as Resource layer, Service oriented architecture layer, Service oriented tool layer and Cloud computing application layer. The Resource layer will hold all the physical resources and logic resources. The physical resources include storage accessories, network equipment, physical database accessories, servers etc. The logic resources include application software and other related software. Service oriented architecture layer performs the sharing of resources as intelligence service, general service and specialty service. Service oriented tool layer provides the user interface and access interface, conducts simulation modeling and debugs the encrypted data.

Military Internet of Things for Intelligence Data Transfer

Military Internet of Things (MIoT) will be an emerging and essential system for connecting all the devices, sensors, drones, satellites and other collection devices under the same military grade network. It will interconnect both human and machines together promoting and exercising human-machine collaboration. MIoT will be comprised of all military platform in addition to collection devices so that the executive deployment instructions can also be passed. This will not only allow the continuous flow of information to the central database but also disseminate the outflow of information to the end users.

RECOMMENDATIONS

With the above discussion on various factors of incorporation of ML in MI process, following recommendations are made:

- ML based collection sources can be incorporated besides traditional collection sources of MI in the area of interest.
- Data fusion center can be introduced to combine and fuse all types of data to make unified intelligence picture.
- R&D can be initiated with collaboration with engineering institutions, government agencies and concerned industries to help promote own innovation and development of ML algorithm and supporting hardware.

- The time line of exploration of ML algorithm with related MI application and platforms can be planned to transform MI process towards human-machine collaboration spectrum.
- The Tiers of intelligence framework can be introduced within the MI framework so that synergistic efforts can bring out automation dividend.
- Security of information has to be ensured in every layer of sources with sufficient updated fire wall system.
- Alternative data storage need to be ensured in every tier of MI process.

CONCLUSION

ML, a subset of AI has been used extensively by militaries of developed and developing nations in their various military applications and war fighting platforms. Supporting this trend, developed countries have reoriented their intelligence collection and analysis process through ML to get more insights about the situation and analyze from all perspective to prepare intelligence database and product. The framework of military ISR incorporate spatial database, attribute database, case base, rule base and a knowledge repository which are intertwined process. The continuous coordination, revision, update and execution can be accelerated through automation with least error probability demands human-machine collaboration in the intelligence analysis framework where the application of ML is evident. Geographic information system (GIS) and knowledge based decision support system (KBDSS) are being used to integrate the function of decision support and knowledge management to enhance both explicit and tacit knowledge base which are the two forms of intelligence knowledge approaches. Incorporation of intelligent operation support system (IOSS) structure through which rich knowledge representation is done by hybrid reasoning strategy which proved its applicability in production decision system. The hierarchy and configuration of MI is broadly divided into three levels; first level consists of operational and tactical intelligence collection organizations and units, second level conducts different intelligence analysis of the data and information provided by the collection organization and units where third level is the user organization, higher headquarters and senior leadership who often place the requirement of intelligence. The data collection and analysis steps in first and second level can incorporate automation by incorporation AI based functioning system.

Recent development in global military application of ML in MI ranges from Multi-Domain Command and Control System (MDC2), Border Surveillance System (BSS), Acoustic Detector, Video Surveillance, Deep Learning for Behavior Recognition and Information extraction through Semantic World Modelling operate under supervised, reinforcement and deep learning approaches to analyze information from Human intelligence (HUMINT), Imagery intelligence (IMINT), Open source intelligence (OMINT), Virtual source

intelligence (VIRINT) and many other sources. The ML algorithm models for MI analysis has been developed and few important achievements in this sector are Active Learning Support Vector Machine (ALVSM), Agent Based Intelligent System Modelling, Ambient Intelligence (AmI), Facial Expression Recognition System (FERS), Data Mining and Data Warehousing, Geographical Information System (GIS) with Sensors and Sensors Based Cognitive Platform.

The Collection, Processing and Analysis (CPA) stages of MI are crucial and need attention from technological aspect as the sheer volume of handing and processing have already exceeded the human capacity as the types of collection sources ranges from sensors, aerial system, satellites, radio signals, open source internet, social network, different organizations, agents, adversaries and many more. In peace time, Non-Traditional Security (NTS) threat remained high throughout the last decade and it has already appeared as new security concern. In war time, under active battlefield scenario, continuous reconnaissance and surveillance are essential and integral part of any operational activities. In battlefield environment, these data from various sources are added to the previous digital database, hence producing massive flow of data. ML system can easily sift through billions of bytes of data and captures the needed types of data to create meaningful information for MI. While ML is applied in collection of data, the system prepares the data by correct identification, locating, profiling, sourcing, integrating, cleansing and storing through data mining. There are various ML approaches which utilizes complex algorithm and predictive modelling for carrying out data analysis for predicting future outcomes. Supervised Learning works with both training and test data set where training dataset can be used to train the ML system by MI agents. Unsupervised Learning is used to find the data structure pattern in the dataset. Reinforcement Learning uses complex algorithm to learn from its experience and redesign its program for analysis of the forecasted situation. Deep Learning function through artificial neural networks where the data are preserved in a number of layers so as to be used through layers of variable data interfaces. In automation of MI, it is found that incorporation of AI brings most impact in processing and analysis stages of MI process. The intrinsic value of ML will thus come for MI organization in promoting and utilizing 'automation dividend' so that agents can use their saved time in other high-priority tasks.

Peace time surveillance is one of the major functions of MI department. Besides manual and human collection of information, sensors, UAVs and EOS can play a dramatic role in collecting large volumes of data and information. Smart security sensors can be interconnected through IoT and can form a large surveillance network system across the border of the country. Surveillance Unmanned Aerial Vehicle (UAV) serves as one of the essential systems to gather image and video data of terrain which are inaccessible and vulnerable through Moving Object Detection and Tracking (MODAT) framework. Earth Observation Satellites (EOS) is an invaluable intelligence collection system covering wide area of terrain

thereby performs as strategic asset of any military. Reinforcement AI learning through supervised algorithm modelling framework can extract the required information from electronic and virtual sources. Data processing by ML algorithm is carried out by data selection (structured, semi-structured and unstructured), data processing, data transformation, data output and finally data storage. Hadoop framework for intelligence data processing performs as Big Data framework for processing and analyzing the intelligence data generated from various sources. Data fusion is the method by ML to process all the types of data into a usable format and prepare a unified picture of ongoing and future situation. ML generally conducts this data fusion through data imperfection, data correlation, data inconsistency and disparateness of data. Among various fusion system, Joint Directors of Laboratories (JDL) model, Dasarthy's framework and Goodman's random sets perform all kinds of data fusion, feature fusion, decision fusion and information fusion. The popular data fusion methodologies are Probabilistic, Evidential, Fuzzy Reasoning, Possibilistic, Rough set theoretic, Hybridization and Random set theoretic fusion. The synthesis of data is an essential step of intelligence data analysis so that it can combine all the disparate elements together as derived from various collection sources for developing intelligence summary of a single event and situation. Military Cloud Computing (MCC) can be a convenient on-demand shared network access for common intelligence data and resources for its dynamic resource pool and storage facility for all intelligence big data and other resources so that any intelligence agent can get access to it at any time in any part of the world and at the same time can upload all kinds of data in any time.

Four Tiers of functionality as data collection, data storage & processing, data fusing and profiling and finally data sharing functions can be developed through functioning of ML by supervised and reinforcement learning method. This will allow expanding the reach of MI all around and physical and virtual areas of interest can be brought under surveillance. So incorporation of ML will facilitate the automation of MI collection and analysis process so that all the corners of own points of interest can be looked into and strategic, operational and tactical leaders are aware of what is coming next.

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REFERENCES

Ahmed, N. U., 2019. Emergence of AI in Future Warfare:Preparedness of BD Armed Forces. NDC Journal, 18(1), pp. 179-209.

Albertus C. van den Broek, J. v. d. V. M. v. d. B. L. N. R. v. H., 2019. Automatic threat evaluation for border security and surveillance. s.l., SPIE.

Alexander Borghgraef, M. V. R. M. A., 2019. Evaluation of acoustic detection of UAVs using machine learning methods. s.l., SPIE.

Alkire, B. et al., 2016. Leveraging the Post to Prepare for the Future of Air Force Intelligence Analysis. RAND.

Almuth Hoffmann, A. K. J. S. F.-I. f. O. S., 2019. Towards information extraction and semantic world modelling to support information management and intelligence creation in defense coalitions. s.l., SPIE.

Anderson, J., 1985. Cognitive Psychology and its Implications. New York: Freeman.

Bhatnagar, R., 2018. Machine Learning and Big Data Processing: A Technological Perspective and Review. Researchgate, p. 468.

Boslaugh, C. J. & Kendrick, Z., 2019. The Application of Data Science in the Intelligence Warfighting Function. Military Intelligence.

Bulao, J., 2020. *https://techjury.net/*. [Online] Available at: *https://techjury.net/blog/how-much-data-is-created-every-day/#gref* [Accessed 03 10 2020].

Chan, B. K., 2020. *https://minddata.org/*. [Online] Available at: *https://minddata.org/artificial-intelligence-data-collection-management-Brian-Ka-Chan-AI* [Accessed 03 10 2020].

Cheng, X. & Liao, X., 2011. The Application of Cloud Computing in Military Intelligence Fusion. Beijing, International Conference of Information Technology, Computer Engineering and Management Sciences.

Chowdhury, O. A., n.d. Big Data to Actionable Decision: An Implementation Roadmap for Bangladesh. NDC Journal.

CLARK, C., 2017. *https://breakingdefense.com*. [Online] Available at: *https://breakingdefense.com/2017/08/rolling-the-marble-bg-saltzman-on-air-forces-multi-domain-c2-system/* [Accessed 15 09 2020].

Connable, B., 2012. Military Intelligence Fusion for Complex Operations: A New Paradigm. RAND NationalDefense Institute.

Council, C. S., 2017. *https://www.newamerica.org/*. [Online] Available at: *https://www.newamerica.org/documents/1959/translation-fulltext-8.1.17.pdf* [Accessed 15 September 2020].

Cruickshank, C. I. J., 2019. On Data Science and Intelligence Analysis. Military Intelligence.

Dasarathy, B., 1994. Decision Fusion. California: s.n.

Defense, D. o., 2018. Summary of the 2018 National Defense Strategy, Washington: Department of Defense.

Desjardins, J., 2019. *https://www.weforum.org*. [Online] Available at: *https://www.weforum.org/agenda/2019/04/how-much-data-is-generated-each-day-cf4bddf29f/* [Accessed 02 10 2020].

Dijk, J., 2019. Artificial Intelligence and Machine Learning in Defense Applications. Strasbourg, France, SPIE.

Dopico, J. R. R., Calle, J. D. d. l. & Sierra, A. P., 2009. Encyclopedia of Artificial Intelligence. Penselvania: IGI Global.

Dornaika, F. & Raducanu, B., 2009. Facial Expression Recognition for HCI Applications. In: J. R. R. Dopico, J. D. d. l. Calle & A. P. Sierra, eds. Encyclopedia of Artificial Intelligence. NY: Information Science Reference.

Electronicsforu, 2018. *https://www.electronicsforu.com*. [Online] Available at: *https://www.electronicsforu.com/market-verticals/aerospace-defence/modern-sensors-defence-military-applications* [Accessed 08 11 2020].

F.E.White, 1991. Data Fusion Lexicon. San Diego: s.n.

Forum, W. E., 2020. *https://intelligence.weforum.org/*. [Online] Available at: *https://intelligence.weforum.org/topics/a1Gb0000001SH21EAG?tab=publications* [Accessed 03 10 2020].

Goodman, I., 1997. Mathmatics of Data Fusion. MA: s.n.

Hamblem, M., 2017. *www.fierceelectronics.com*. [Online] Available at: *https://www.fierceelectronics.com/components/sensors-artificial-intelligence-and-concepts-you-may-want-to-know-i* [Accessed 28 9 2020].

Hedlund, G., 1994. A Model of Knowledge Management and the N-form Corporation.. Strategic Management, 15(73-90).

Ibrahim, A. W. N. et al., 2010. Moving Object Detection and Tracking Framework for UAV-based Surveillance. IEEE Computer Society, Volume 83, pp. 456-462.

I, N., K, U. & D, S., 1996. From Information Processing to Knowledge Creation: A Paradigm Shift in Business Management. Technology in Society, 18(203-18).

Jiang, J. & Horace, H. S., 2009. Active Learning with SVM. In: Encyclopedia of Artificial Intelligence. NY: Information Science Reference.

Khaleghi, B., Khamis, A. & Karray, F. O., 2011. Multisensor Data Fusion:A Review of the State-of-the-Art. Information Fusion-Elsevier.

Liao, S.-H., Sun, B.-L. & Wang, R.-Y., 2003. A Knowledge-based Architecture for Planning Military Intelligence, Surveillance and Reconnaissance. Science Direct, 19 (2003)(191-202), pp. 191-202.

M.M.Kokar, J.A.Tomasik & J.Weyman, 2004. Formalizing Classes of Information Fusion System. Information Fusion.

M.Tortonesi, et al., 2016. Leveraging Internet of Things within the Military Network Environment – Challenges and Solutions. VA,USA, IEEE 3rd World Forum on Internet of Things (WF-IoT).

Maria Andersson, F.-S. D. R. A., 2019. Deep learning for behaviour recognition in surveillance applications. s.l., s.n.

Matheson, R., 2020. *https://news.mit.edu/*. [Online] Available at: *https://news.mit.edu/2020/artificial-intelligence-digital-maps-0123* [Accessed 28 09 2020].

M, H., 2015. Redifining Military Intelligence Using Big Data Analytics. Scholar Warrior, 72(Autumn 2015), pp. 72-78.

Mitchell, K. et al., 2019. The Future of Intelligence Analysis. Deloitte Insights.

O'Hanlon, M., 2019. Forecasting Change in Military Technology,2020-2040. Foreign Policy at Brookings.

Oliver, C., E, D. & B, I., 1997. Enhancing Run off Modelling with GIS: Landscape and Urban Planning. s.l.:s.n.

Pant, A., 2019. Internet of Things Centricity of Future Military Operations. Journal of Defense Studies, 13(2), pp. 25-58.

Pasricha, H., 2020. *https://www.domo.com*. [Online] Available at: *https://www.domo.com/learn/data-never-sleeps-5?aid=ogsm072517_1&sf100871281=1* [Accessed 03 10 2020].

Prelipcien, G., Boscoianu, M. & Moisescu, F., 2010. New Ideas on the Artificial Intelligence Support in Military Applications. London, WSEAS Press.

Sadri, F. & Stathis, K., 2009. Ambient Intelligence. In: J. R. R. Dopico, J. D. d. l. Calle & A. P. Sierra, eds. Encyclopedia of Artificial Intelligence. s.l.:Information Science Reference.

Shu-Hsien, Sun, B.-L. & Wang, R.-Y., 2003. A Knowledge Based Architecture for Planning Military Intelligence, Surveillance and Reconnaisance. Elsevier, Issue Science Direct, pp. 191-202.

Simonite, T., 2017. *https://www.wired.com/*. [Online] Available at: *https://www.wired.com/story/for-superpowers-artificial-intelligence-fuels-new-global-arms-race* [Accessed 15 September 2020].

Tang, Z., Huang, X. & Bagchi, K., 2009. Agent Based Intelligent System Modelling. In: J. R. R. Dopico, J. D. d. l. Calle & A. P. Sierra, eds. Encyclopedia of Artificial Intelligence. NY: Information Science Reference.

Vanessa Buhrmester, A.-K. G. D. M. M. A., 2019. Augmentation techniques for video surveillance in the visible and thermal spectral range. s.l., SPIE.

Wang, J., Chen, Q. & Yao, J., 2009. Data Miming Fundamental Concepts and Critical Issues. In: J. R. R. Dopico, J. D. d. l. Calle & A. P. Sierra, eds. Encyclopedia of Artificial Intelligence. NY: Information Science Reference.

WEISGERBER, M., 2017. *https://www.defenseone.com*. [Online] Available at: *https://www.defenseone.com/technology/2017/05/pentagons-new-algorithmic-warfare-cell-gets-its-first-mission-hunt-isis/137833/* [Accessed 15 09 2020].

Xia, Q. & Rao, M., 1999. Knowledge Architecture and System Design for Intelligent Operation Support System. Expert System with Applications, 17(115-27).

Zhang, Z. & Griffith, D., 1997. Developing User-friendly Spatial Statistical Analysis Modules for GIS. Computers Environmnet and Urban System, 21(5-29).

Zhou, Z., 2003. Three Perspective of Data Mining. Artificcial Intelligence, 14(139-146).

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