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AI SYSTEMS AND TESTING FOR AERIAL COMBAT

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***Abstract*—Artificial intelligence systems are used in aviation like autopilot systems, UAVs, Drones, etc., AI in near future would revolutionize aviation industry assisting the fighter pilotsduring aerial combat beyond their human abilities. The need for assistance of AI systems for combat emerged with the evolution of Unmanned Aerial Vehicles. Technology can identify, manipulate, and act faster than human beings helping the fighter pilots to cover them during a combat and handle the adversaries at the same time so that the pilots move on with their next target. The environment for civil or commercial aviation automation is not the same for the military aviation. It must be smart and swift to decide and execute the counter measures. There by effective and artificially intelligent algorithms and systems is required right from the beginning of the development till the live execution. This paper aims in discussing the major concerns in developing and testing AI systems specific for air combat gathered from various articles, accident and incident reports and resources.**

***Keywords*—AI systems, fighter pilots, autopilot, aerial combat, development, testing, UAV, drones, and unmanned aerial combat vehicle.**

I. INTRODUCTION

AI systems uses machine learning algorithms, repeated, reinforcement learning methods to understand the system completely and act based on the data acquired through repeated learning procedure. In a normal aircraft, AI can be used for navigation, sensors, crew interaction and passenger facilitation. It mostly involves defined sequences of regular actions. Whereas, for a military aircraft during air combat the environment and the approaches for the scenarios are very dynamic. A fraction of second would cost a life. Thus, AI systems must be very carefully designed to assist the fighter pilots during air combat with minimal supervision like in a formation by adversary, the pilot would order the AI system to engage few adversaries while he could take care of the rest. Current trend involves assistance to the fighter pilots whereas in near future UAVs would be self-competent for the aerial combat.

II. CONCERNS IN DEVELOPMENT AND TESTING OF AI SYSTEMS

A. Object identification:

While developing autopilot system, the system must be able to recognize the types of aircrafts in action like UAVs, non-fighter drones, heterogeneous swarm drones, multi rotor drones, fixed wing drones, tilt wing, multi-copter,unmanned copter etc.Sensors and radars mostly do this process of identifying the fighter aircraft. Butanalyzing and identifying drones and UAVs require deep learning and analysisof the structure, functional features, RF signals, IR signals, audio detection, video detection, motion detection, thermal detection techniques thus widening the context of object screening and identification.AI system should have highly efficient, and reliable performance in object identification as it is the first step towards interpreting the enemies which should be consider as the primary requirement. Object identification is not only important for maneuver but also to avoid any collision between the air vehicles using sense and avoid technique.A complete analysis of all types of aerial vehicles must be done precisely more like a biological DNA analysis.

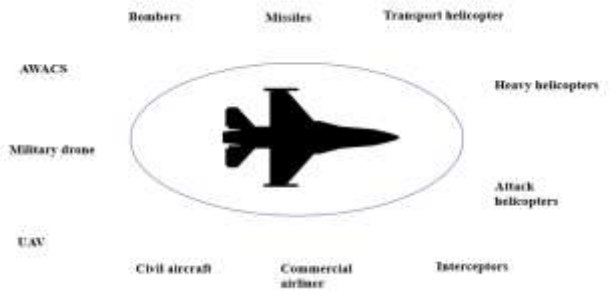

Figure 1. Types of air vehicles

B. Maneuvers:

AI system is required to handle an adversary to cover the fighter pilot. The system handles the situation based on the data provided for the algorithm during learning. Practically, there are very difficult maneuvers or combinations of maneuvers or formations which requires a human fighter pilot who can analyze and predict the maneuver and act accordingly at given instant. This super smart AI system must also predict and act in an instant. Next, the environment plays a major role. If there is a combination of UAVs, drones or missiles, the algorithm to tackle

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adversaries from different sources and different types is mandatory. These maneuvers and environment learnings for AI system must be made feasible to 100%where the difficultylies in vast and exhaustive collection of data from the ace pilots. AI systems must also be configured with sensor parameters and deterministic algorithms to sense, estimate and avoid collision or interference with the any aircraft.

C. LethalAutonomous Weapon Systems:

There are many beyond visual range air to air(BVRAAM),surface to air(SAR), air to surfaceballistic missilesfor aerial combat. The role of AI system includes dodging these missiles. Sensors must sense beyond range for the system to identify severalmissiles launches from multiple sources very quickly. Concern arises in testing of this AI system feature. Though one can simulate the missile launch from air and surface, the environment, the actual atmosphere would include fog, rain, lightning, and many other natural phenomena obstructing the sensing efficiency. The density of the fog could vary, it might be pouring heavily, a massive thunder could obstruct, and many other natural obstructions must be considered. It must also identify which missiles are launched by the enemies and the ones launched by their own pilots.AI as autopilot system to assist fighter pilot is a critical life safety system which must not be prone to errors as it incurs cost of life and a country's reputation as price for theunidentified bug. Testing AI system with such atmosphere which could be more expensive, and lot of circumstantial occurrences must be considered as an important factor while designing and testing.

D. GPS interference:

The main functionality of the AI system would be jamming the GPS signals of the adversaries. So, to conduct a test before the actual warfare, a military aircraft did GPS interference testing though with a prior notification sent to the respective areas. But, based on an article published in February 2021 [1], latest even last year as per report, a commercial airliner reported loss of GPS position. It was learnt that it was not the aircraft fault but was due to GPS interference testing. Similarly, other pilot was forced to controlled flight into terrain for the same reason, nearly 90 reports for GPS interference have been logged in US over past 8 eight and mostly it was between 2019 and 2020. This would cost the life of passengers and crew travelling in the aircraft. The military tests for GPS interference must be done in way that does not affect civil or commercial airliners and the Air Traffic Control Systems. GPS are often vulnerable to attack. When the signal reaches ground it becomes weak and can be easily interference. It is essential that the AI systems supporting in aerial combat should be developed against GPS denial and other counter electronic warfare systems.It must also be capable of not jamming the civil aircraft and ensure the pilot doesnot lose control over it. There is a need to establish resilient navigation and surveillance infrastructure enabling the fighter aircrafts to overcome the GPS outage.

Figure 2. GPS interference

E. Parallel processing:

The AI systems for tackling aerial combat resides in the pilot cockpit with other devices and controls. The system must process parallelly which should not interfere with the pilot's maneuver. If the system is assigned to engage the enemy, then it must independently work on it without much sharing of other controls because if this happened ultimately the pilot would lose over the control of the aircraft. The radars, sensors and signals must not override the existing data. AI system algorithm must be practiced through state of art technique including such scenarios. Air Traffic Control systems must also not be affected. Making intelligent systems does specify the intelligence on executing the task but not overriding it causing a life threat. The other major concern arises here is integration of these latest AI systems into existing hardware. AI system design must be done by proper analysis of existing hardware and the software component that could communicate with the hardware without much cost or modification. The data from the transponders and radars areused as learning data for the AI algorithm. The data used must possibly cover all types of embedded components. Testing multi sensor intelligence is the next step. There are more chances of false results. Currently most object trackers use individual sensors. As mentioned in the above section the system must work on heterogenous sensors, different sample rates, multiple bandwidths, RF signals, wide array of communication equipment etc.,Hence AI system design and test must exceedhuman abilities in interpreting and train it with these parallel processing scenarios with several aircrafts.

F. Autopilot systems:

The fighter pilot assigns the task to engage the adversary to the AI system. From here, the AI system should auto pilot the UAVs for their maneuver against the enemy aircrafts. The design of auto pilot system works on many factors like

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position, wind speed, altitude, navigation etc., Thus it could direct the UAVs right from the launch till the mission accomplishment.The auto pilot system in AI decides the UAV's control movements. Once it is decided then the autopilot carry out the task of these control movements through sensors. Thus, AI system and its auto pilot feature must function on multiple aircraft and multiple sensors.The report and result of operations carried out is passed to the pilot and the ground station.

G. Environmental factors:

The design and development process should be carefully done considering influential factors. But when it comes to implementation and testing of hardware components of AI systems for aerial combat, external environmental factors play a very critical role. Features like lightning protecting, corrosion prevention, in-flight airframe icing are designed for the aircrafts to protect it from external climatic conditions. Still the sensors used must be able to tackle the fog density, avoid misinterpretation of fog as object, work during rain, thunder, and lightning conditions too. Testing the system with such real time conditions during simulation is onerous job. The sturdy environment factors should be tested live for predicting accurate behaviour.The AI system must be all weather qualified system capable of performing data processing, documentation, tracking, movement controls, and all other features. Implementation and testing under such environment are the major challenges of AI systems.

H. Software:

Software is a key feature as it interacts with the hardware and also interacts with the user. The software designed must be secure, stable and must have high reliability and performance.The user interface must be simple and easy to operate without much complexity. Proper visual mode must be enabled to get a clear picture of the environment.

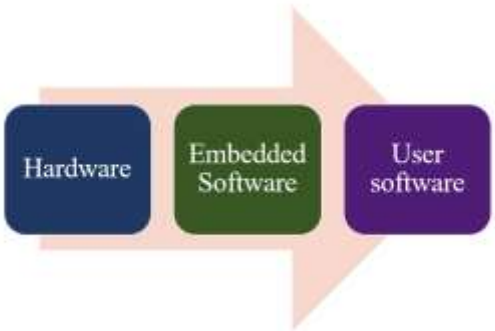

Figure 3.High level AI system components

The hardware component refers to the physical components like sensors and other multiple system hardware components. The embedded software interacts with the hardware and gets the data from it and starts processing through AL codes or algorithms. Then in the user software the data is presented where an interactive communication would occur with the pilot. Testing of software is not easy as like the traditional ones, where there is a confirmed expected output against input. But in AI system the data is captured from real time systems and the behaviour might vary post training process as all the scenarios might not have been included. Collection of massive volume of data from multiple sensors cause noisy data set. Quality of data for training and the algorithm chosen impacts the efficiency directly. Data validity and reliability is another important attribute. There is an integration of components in AI systems making more vulnerable for threats. Security testing and reliability must be tested exhaustively. Numerous approaches are available for testing like Model in the loop, hardware in the loop, software in the loop techniques.A good testing would enable the human fighter to completely take over the control of the system with ease in case of any error or malfunction in the system. The software testing needs such negative exception catching scenarios which is quite difficult to interpret as the system is based on unanticipated random events of attacks.Thus, software is very crucial for design, development, and testing. Exhaustive testing is mandated to ensure the pilot's safety.

I. Stability and reliability:

The fighter aerial vehicles used by AI systems must be highly stable, secure, and consistent in handling adversaries. It is essential to establish a drone-to-drone communication for formations, and drone-to-ground station communication to pass the data from its visual and beyond visual range. Standardization must be made for such communication protocols as they are vulnerable to jamming by P2P attacks, DoS attacks.The aircraft during combat changes its altitude and position dynamically within a fraction of second. AI systems must be very stable and continuously monitor every position carefully and update immediately.AI systems and the sensors must be resistant to any jamming of GPS signal in such a way if the pilot loses signal AI system must back up the pilot with the current location. It should also alert the fighter pilot in case if he is crossing the boundary unknowingly. In an adverse condition despite all the tactics if the fighter craft is hit and about to crash, AI system should predict and display the nearest safest landing point and accurate time in seconds left out for safety ejection. There could be a simple wrist map watch tied to every fighter pilot. The AI system would constantly update the pilot's wristwatch in specific intervals regarding the current location and the surrounding map area making it available offline too. Thereby, just in case if any crash happens to the aircraft, the pilot's watch would have the latest information regarding the location and the map updated by the AI system. Since the watch has only data about the map and safe location it would not pose any serious data threats.It would help for safe landing after ejection. After the pilot's

ejection, the system must erase all the classified confidential data in the aircraft prior to crashing. AI system must be stable, secure,and reliable for the pilot during and after the aerial combat.

III. CONCLUSION

AI systems would be a technology backbone for our fighter pilots during aerial combats which would help them in diverse attack platforms confusing and overwhelming the enemies. In this discussed feature, the fighter pilots are the commanders of the AI systems directing AI systems to autopilot the Unmanned Aerial Combat Vehicleduring dogfights or any other combats. The AI systems are trained on every minute details and intelligence from the fighters which would help the pilots in just giving the high-level command to the AI system during combat without detailing much. This would facilitate the fighter pilot to move on to handling other adversaries and AI systems helps in tackling situations beyond his visual range or human abilities. AI system should win the trust of the pilot which is equally important to the task efficiency. Apart from the challenges and concerns listed in the above sections winning the trust is the biggest challenge as the pilot considers the system as a backing. The AI system should be trained on state of art, reinforcement, and other learning algorithmsfrom simple to complex scenarios with common and unique encounters made by the pilots with their flying experience.Security is a very critical mandatory element, and the AI system must be immune to any attack which makes it highly reliable. Designing and testing highly standard, efficient multi-tasking AI systems with detailed and deep learning algorithms focusing on the concerns listed would result in effective aid the fighter pilots for aerial combats.

IV REFERENCES

[1]. Mark Harris, “FAA Files Reveal a Surprising Threat to Airline Safety: the U.S. Military's GPSTests”, IEEE Spectrum: Technology, Engineering, and Science News, 21 January,2021.

[2]. SKYbrary Wiki,” Cockpit Automation - Advantages and Safety Challenges - SKYbrary Aviation Safety.” [Online]. Available: https://www.skybrary.aero/index.php/Cockpit_Automation_-_Advantages_and_Safety_Challenges. [Accessed: 06-May-2021].

[3]. DEDRONE, “DroneTracker Counter-Drone Software,” Dedrone. [Online]. Available: https://www.dedrone.com/products/counter-drone-software. [Accessed: 06-May-2021].

[4]. W. Knight, “AI Could Enable 'Swarm Warfare' for Tomorrow's Fighter Jets,” Wired. [Online]. Available: https://www.wired.com/story/ai-enable-swarm-warfare-fighter-jets/#intcid=_wired-amp-bottom recirc_c70a9e88-4b7a-44bc-bb32-5c021163abf4_text2vec1. [Accessed: 06-May-2021].

[5]. Robert Harwood, “The challenges in developing fully autonomous drone technology”. [Online]. Available: https://www.ansys.com/blog/challenges-developing-fully-autonomous-drone-technology. [Accessed:06-May-2021].

[6]. Boris Shiklo, “Tips and predictions for drone software development”. [Online]. Available: https://www.scnsoft.com/blog/drone-software-development. [Accessed:06-May-2021].

[7]. Margarita Konaev, Tina Huang and Husanjot Chahal. “Human-machine teaming and the future of military AI”, CSET Analysis. February,2021.

[8]. Yaacoub, J. P., Noura, H., Salman, O., & Chehab, A. Security analysis of drones systems: Attacks, limitations, andrecommendations. Internet of Things Journal.2021.

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