Situation Awareness Exchange Methods for a Swarm of Autonomous Systems

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The future system of distributing situation awareness (SA) for a swarm of autonomous systems (UxV) should be built on the basis of networking principle as the part of an integrated, hierarchical, multidimensional and multiple networks system on the battlefield. She should be adaptive to role and mission of such swarm as well.

In this regard for the transfer of situation awareness data can be used real-time Data Distribution Service (DDS) over a wireless IP network based on ROS-2 (Robotic Operating System) or a similar version of ROS-M. As the dissemination protocol of data can also use a combination of DDS with MQTT-SN, which is a publish/subscribe messaging transport that was designed for vehicle-to-vehicle telemetry, sensors networks and is now a major protocol of IoT. To reduce jitter and latency within networks can be used the integration of DDS with Time-Sensitive Networking (DDS-TSN), which will have the jitter on a level not more than a few microseconds.

The other aspect of situation awareness exchange is the balance between preloaded data to board autonomous systems and SA data, which update after starting the mission. In this context should be considered transfer of Augmented Reality (AR) data as the main type of data in the future battlefield and as means and an information’s bridge to connect commanders with Join Artificial Intelligence (AI) of UxVs swarm.

In the future, after increasing the autonomy of robotic UxVs and the integration of human perception analogues, such in the physical vision, into robotics, the part of AR data from BMS should be transferred to UxVs for use by its autopilot for orientation and support of mission [1]. For this it is possible to preload the necessary volumes of AR data before the start of the UxVs mission, as well as quickly update them on board the UxVs during the execution of the task.

In case of the Remotely Controlled UxVs the overlaying of preloaded AR symbols to the video stream from the UxV on-board cameras should be make in the UxV equipment with the next transmission a full ready combination preloaded AR and video stream to the UxV's operator [1]. Such a solution decreases navigation errors and exclude additional mistakes such as operator localization in the placing AR symbols in correct position on the terrain image [1]. This improves the accuracy of targeting acquisition and situation awareness.

At the same time, AR outline symbols of targets will be synthesized as AR data on the base of Point Cloud from UxV onboard vision sensors by using AI algorithms [1]. Also, AI can perform the following functions [1]: warnings about the possibility of capsizing, determining a safe path, detecting suddenly emerging threats that impede movement, visual warning for marking areas requiring special attention, the analysis of hyperspectral images of the soil to identify changes in its surface, which is a sign of artificial camouflage of improvised explosive devices or mines, camouflage identification against the backdrop of a natural landscape. All results of such identification will be present as AR symbols. Such synthesized AR symbols can be sent to the operator of Command post or other autonomous systems inside Manned and Unmanned Teams (MUM-T) without video stream for minimization of traffic or incorporate into the full video stream in the combination with preloaded AR symbols as well [1]. In this case, it is necessary to solve the problem of integrating the onboard AR data generation tools with the UxV architecture, as well as to find a compromise in the level of centralization of their connection to the BMS [1]. It is very important inside MUM-T as well.

AI algorithms can build not only outline AR symbols of targets but also synthesis they AR vulnerability models, similar such as the German VEMAG model, Swiss RUAG model, US MILES LEAR model, and French GDI model, which use now for modeling and simulations [1]. Synthesized by help of Artificial Intelligence the vulnerability model of target decompose enemy object into few sides and those sides into some areas for hitting, allowing for a more precise regards between point of impact and specific damage effect. The information about such hitting areas can be distributed as AR symbols between few networked effectors to coherent/together destroy of difficult target. Furthermore, AI can be used to visually identify objects and targets on the battlefield. A cloud or multi-platform cooperative AI algorithm, which is distributed between several UxV with different viewpoints, even allows deriving three-dimensional geometry in order to generate more accurate AR symbology for an improved common operational picture.

For the transfer of AR data between UxV inside swarm, VANETs (vehicle ad-hoc networks) and blockchain principles can be used, which should be updated to Barrage Relay Networks (BRNs) similar to such MANETs presented. The challenge with UxV swarm communications directly to combat vehicles is the uniqueness of the data links utilized by these platforms. For example, the most common UAV data link, in many coalition forces, is Common Data Link (CDL) or other similar instantiations of STANAG 7085.

As stakeholder and distributor of Augmented Reality Data for the Future Battlefield can be used FMN (Federated Mission Networking). It will be possible in the context of the migration of FMN into tactical level. FMN can be used also as the mean of the information filtering AR data for every tactical unit and UxV swarm in the context of roles of such units in the mission. An analysis of the activities of all FMN’s spirals leads to the conclusion that the introduction of AR in FMN can already be started within the framework of the spiral No. 5 in order to form a common picture of the battlefield, information management on intelligence, incidents and sudden events. The prototype for the Tactical AR database should be NATO's existing Battlefield Information Collection and Exploitation Systems (BICES) and Logistics Functional Area Services, which provide joint operational - logistic picture.

FMN can be used as the cloud for AR Data to enhance Joint Situational Awareness by providing common cross-community distribution. This cloud stores actual data, which is used to build the following typical categories of annotated AR tactical symbols: friendly unit positions, Blue Force Events, leading edge and enemy positions (historical, current and forecast), Enemy Attack Positions (current/suspected; historic), Enemy Engagement Zones (current/suspected; historic), locations of improvised explosive devices (history, detected but not destroyed, probable or suspected), subsurface infrastructure (culverts, sewer, utilities), roads, bridges, cleared CASEVAC Helicopter Landing Zones, local cultural sites and more. All these data can be downloaded to the command post of swarm of autonomous systems for build of AR before the start of combat mission and can be updated after the beginning of the mission by wireless communication means. Each UxV inside tactical swarm can have direct access with personal ID password to AR data of a tactical level FMN cloud. But also the other variant can be implemented – the connection to FMN cloud has only commander's UxV, which shares AR data with its peers. Such solution minimize a cost by downloads of AR data from FMN clouds. In any case the commander post of swarm will have a role the data center of autonomous systems swarm.

As an important parameter of the minimum capability requirements for AR data tactical systems in the context use cases of UxV swarms should be specified in the distance, in which framework need have situational awareness. Regarding a battalion's tactical group level such area radius should be 15-30 km [2]. It is not the range between tactical units, it is the radius of area, in which should be supported and provided the prompt generation of information at the command post of the UxV swarm to realize AR services for situation awareness of swarm of autonomous systems. On the other hand, it is necessary to determine the nearest areas around the swarm, which should ensure safety and avoid contact with environmental elements.

The interoperability of situation awareness systems of different nations need to standardize the architecture of autonomous systems swarm, roles and relationship between master and slaves UxVs inside swarm, data format etc. In this context can be say about System of Systems of Standards [3] regarding situation awareness for a swarm of autonomous systems, which should be built.

References

1. Slyusar V.I. The role of Artificial Intelligence in cross-platform tailoring of AR data. // Coordination problems of military technical and defensive industrial policy in Ukraine. Weapons and military equipment development perspectives/ VIII International Scientific and Practical Conference. Abstracts of reports. - October, 2020. - Kyiv. - https://slyusar.kiev.ua/CONFFERENCE1_AI.pdf. - DOI: 10.13140/RG.2.2.22122.13760.

2. Slyusar V.I. Battalion tactical group 2035. //Coordination problems of military technical and defensive industrial policy in Ukraine. Weapons and military equipment development perspectives/ V International Scientific and Practical Conference. Abstracts of reports. - October 11–12, 2017. - Kyiv. - P. 37. - http://slyusar.kiev.ua/en/V_conf-2017_ENG_1.pdf.

3. Slyusar V.I. Regarding the building of system of systems of standards. //Coordination problems of military technical and defensive industrial policy in Ukraine. Weapons and military equipment development perspectives/ V International Scientific and Practical Conference. Abstracts of reports. - October 11–12, 2017. - Kyiv. - P. 38. - http://slyusar.kiev.ua/en/V_conf-2017_ENG_2.pdf.