

Framework Development of Intelligence, Surveillance, and Reconnaissance (ISR) Based Geographic Information System for Common Operating Picture (COP) to Support Damai Cartenz Operation

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Abstract—Operation Damai Cartenz is a joint operation between the Indonesian National Police (POLRI) and the Indonesian National Armed Forces (TNI) in the Papua region to face security challenges in the region. The rugged terrain and complex operational environment in the Papua region are one of the challenges in carrying out this operation, so a strategy is needed to run it, one of which is by utilizing a Geographic Information System (GIS). The Geographic Information System (GIS) is one of the pieces of information that can assist officials in mapping areas. The application of GIS in operations can be further developed through the use of information resources owned by the Task Force. One of the things that can be done is by integrating Intelligence, Surveillance, and Reconnaissance (ISR) and Common Operating Picture (COP) capabilities in GIS. The main objective of this research is to be able to develop and offer a conceptual framework for integrating ISR and COP capabilities for GIS in supporting the Cartenz Peaceful Operation in the Papua region which includes explanations regarding requirements and addressing operational challenges through the implementation of effective integration of ISR and COP capabilities.

Keywords: Intelligence, Surveillance, and Reconnaissance; Common Operating Picture; Geographic Information System

1. INTRODUCTION

Operation Damai Cartenz is a joint operation between the Indonesian National Police (POLRI) and the Indonesian National Army (TNI) in the Papua region to deal with security challenges in the region which includes a series of attacks including attacks on civilians and security forces [1]. Based on interviews with the Head of the Papua Regional Police, there are at least six conflict-prone areas in Papua, including Puncak Jaya, Puncak, Nduga, Intan Jaya, Yakuhimo, and Pegunungan Bintang [2]. Figure 1 shows the topographical map of Nduga Regency as one of the areas with a high level of vulnerability.

Based on Figure 1 and Figure 2, it can be seen that the majority of the operational areas are mountainous and have dense forests. The rugged terrain and complex operational environment in the Papua region are one of the challenges in carrying out this operation, so a strategy is needed to carry it out [3]. One way that can be done to carry out these operations is to build a Common Operating Picture (COP). COP is a concept that refers to an understanding between stakeholders in understanding the operational environment. COP is based on the concept that the military can increase situational awareness, accelerate decision-making and information synchronization based on information exchange and collaboration [4].

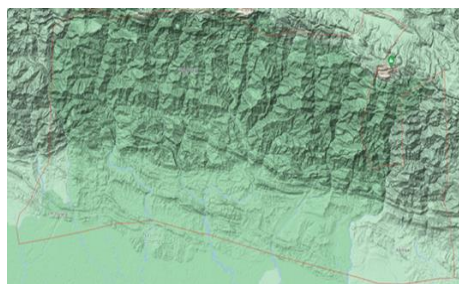


Figure 1. Nduga Map from Satellite Photo Retrieved from Google on 2023



Figure 2. Nduga Topography Map Retrieved from Google on 2023

There are three keys to COP, the first is a shared information network where all stakeholders can access the same information thereby accelerating the exchange of information between stakeholders. The second is real-time data and information where all stakeholders have an understanding of ongoing operations based on real-time data and information obtained. The third key is collaboration in decision making which allows stakeholders to respond more quickly in dealing with changing field situations because decision-making is carried out in collaboration and consensus building [5].

But with the development of technology, now the battle is not limited to physical contact but also information warfare. Accurate field information is very much needed in building COP to carry out operations in Papua. The Global Information System (GIS) is one of the pieces of information that can assist officials in mapping areas. GIS is a computer-based system capable of collecting, storing, analyzing, and visualizing geospatial data [6]. The application of GIS in operations can be further developed through the use of information resources owned by the Task Force. One of the things that can be done is by implementing Intelligence, Surveillance, and Reconnaissance (ISR) capabilities in GIS.

Intelligence, Surveillance, and Reconnaissance (ISR) is a process of collecting, processing, analyzing, and disseminating all information related to and supporting operations to facilitate troop leaders in making the right decisions to achieve mission success [7]. ISR consists of three main components, the first component is intelligence where the process of analyzing information is carried out to obtain a clear picture of the operational environment. The next component is surveillance, where the process of collecting data in real-time uses the available resources. The last component is reconnaissance, which collects information regarding enemy dispositions and activities through ground patrols [8]. The implementation of ISR capabilities can provide real-time situations on the ground, especially reading the direction of attack and mapping the location of armed criminal groups, so that the task force can help make the right and fast decisions. With various assets owned by the TNI-POLRI Task Force, such as unmanned aerial vehicles (UAVs), ground-based sensors, and human intelligence sources, this is a potential that can support successful operations. However, this potential cannot be utilized optimally because these assets are not fully integrated or coordinated with each other. So that this can cause information overload, miscommunication, and delays in decision-making which result in the level of effectiveness of the operations being carried out [9].

Despite the strides made in the field of Intelligence, Surveillance, and Reconnaissance (ISR), a conspicuous gap persists in its practical implementation. Presently, ISR is predominantly utilized for information collection through sensors, yet there exists a notable deficit in visualizing the acquired data [7] [8]. Simultaneously, within the realm of Geographic Information Systems (GIS) research, there remains an unexplored space wherein data obtained through ISR is not seamlessly integrated [6]. This observation underscores a critical deficiency in prior research, specifically the underutilization of ISR and GIS integration, particularly in the construction of a Common Operational Picture (COP) to bolster activities within security operations. In light of these challenges, it becomes evident that further research is imperative to address the identified gaps and pave the way for the development of an effective framework facilitating the seamless integration of ISR with GIS. Such an integrated approach holds significant potential in enhancing operational activities in the field, particularly within the context of security operations.

The main objective of this research is to be able to develop and offer a conceptual framework for implementing ISR capabilities on GIS to build a Common Operating Picture in support of the Damai Cartenz Operation in the Papua region which includes explanations regarding requirements and addressing operational challenges through the implementation of ISR. The scope of this research will be limited to the development of a framework concept in implementing ISR capabilities on GIS to build a Common Operating Picture in support of the Damai Cartenz Operation and has not yet reached the implementation stage of the framework. This research is expected to provide a valuable contribution to the development of implementing ISR capabilities on GIS for building a Common Operating Picture in support of the Damai Cartenz Operation.

2. RESEARCH METHODOLOGY

To get output in research, an appropriate methodology is needed in order to get the best results. Figure 3 shows a schematic research methodology in developing the framework [10]. The following is an explanation at each stage.

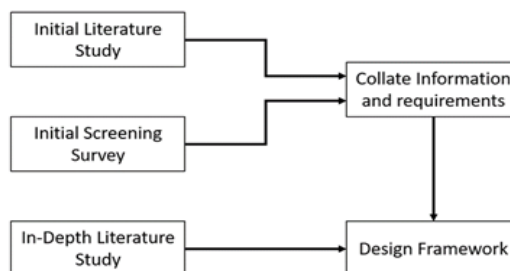


Figure 3. Research Methodology for Framework Development [10]

a. Initial Literature Study

At this stage it focuses on searching the study literature on the application of ISR and COP in wider application. Based on the literature studies that have been conducted, it was found that the application of ISR and COP has reached various fields, ranging from development for radars, Unmanned Surface Vehicles, to development using certain algorithms, but there has been no research that has focused on developing a GIS framework with ISR implementation to build a COP.

b. Initial Screening Survey

At this stage the focus is on finding a situational picture related to the operation being carried out. This information comes from the results of interviews conducted by the media with relevant authorities, such as the Task Force Commander, the Commander of the TNI Operations Command, and other parties involved in carrying out operations. Based on interviews conducted from various sources, information can be obtained that there are still attacks by armed criminal groups on law enforcement officials so that the operational area is still on standby status and currently operations prioritize three functions, namely intelligence, community development, and public relations.

c. In-Depth Literature Study

This stage focuses on the design, methods, and processes used in the development of an ISR-based GIS framework. Based on the literature, further studies that have been carried out suggest that the use of ISR and COP has been narrowed and focuses on the practical use of ISR and COP. In Table I is research related to the implementation of ISR and COP. Based on Table I, it can be seen that ISR and COP have great potential if these two things can be integrated. This research focuses on designing the integration concept of ISR and COP which is the main supporting data for GIS in supporting military operations.

Table 1. Related Research

Author	Result
Brandfass et al [11]	The performance of the PrecISR™ Radar family has been demonstrated through various surveillance and reconnaissance examples, highlighting its exceptional capabilities, similar to the AESA Pod Radar System.
Yu and Lee [12]	The architecture is implemented in the USV system, validated through sea trials, but further research is needed to optimize mission plans for maximum operational effectiveness.
Puuska et al [13]	The prototype helped assess and improve the resiliency of interconnected critical infrastructure networks, offering a two-level interactive tool that combines network automation with human decision-making processes. The framework allows for rapid prototyping of COP solutions and simulation of CI failures during various incidents.
Robert J. Hall [14]	Implemented using smartphones, experiments confirm the scalability up to 20 devices, outperforming other approaches with n2 complexity that struggle in dynamic field conditions. This study provides promising evidence for further research and extension to diverse monitored information.
Ales and Ladislav [15]	This paper examines the processing of ISR data and the integration of Data Warehousing, Business Intelligence, and Data Mining technologies to handle the diverse data types. It presents the construction of a customized data mart for ISR data and demonstrates the graphical visualization of Data Mining results, emphasizing the benefits of Business Intelligence for commanders' decision-making.

d. Design Framework

At this stage, the framework design is carried out based on the information and needs obtained in the previous stage. This stage also includes planning the selection of technology to be used, how each entity works, and how to communicate between entities. Furthermore, the results of the design at this stage can be seen in the next section.

3. RESULT AND DISCUSSION

This section will discuss the results of the design and the workings of the design in supporting operational activities. There are several parts in this development which can be seen in Figure 4. Based on Figure 4, ISR is implemented based on intelligence information either through sensors or reports originating from human intelligence. Sensors in this system include motion and sound sensors. The sensor functions to detect the direction of movement of both friends and foes based on the source of the gunshots. With this sensor, the security forces can know more clearly the direction of the shot in the event of an attack. Data from the sensor is transmitted using LoRa. The LoRa communication topology used was adapted from a previously developed forest environmental monitoring system by adding a sensor to detect the direction of sound [16].

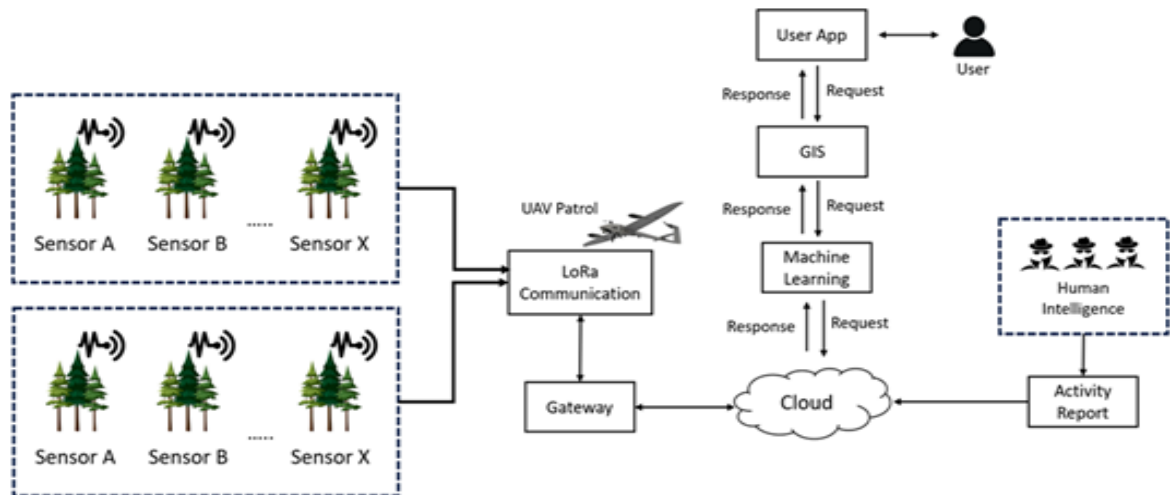


Figure 4. General Concept Framework [16]

The choice of LoRa was based on several considerations, including requiring relatively less power but having a wide data transmission coverage and minimal interference, so it is considered suitable for transmitting data from within the forest [16]. Based on the designed topology, the placement of sensors will be scattered at various points to get optimal results. In addition, the sensors used will be embedded in LoRa-based communications and these sensors will later send data to the edge gateway. While the IoT edge gateway that will be used later will be based on edge computing which will allow analyzing the gateway. After the gateway analyzes the data that has been obtained, the data will be forwarded to the cloud server via IP. However, there is a difference from the previous development, namely the addition of an acoustic sensor which will later function to detect the direction of attack or shot. The design can be seen in Figure 5.

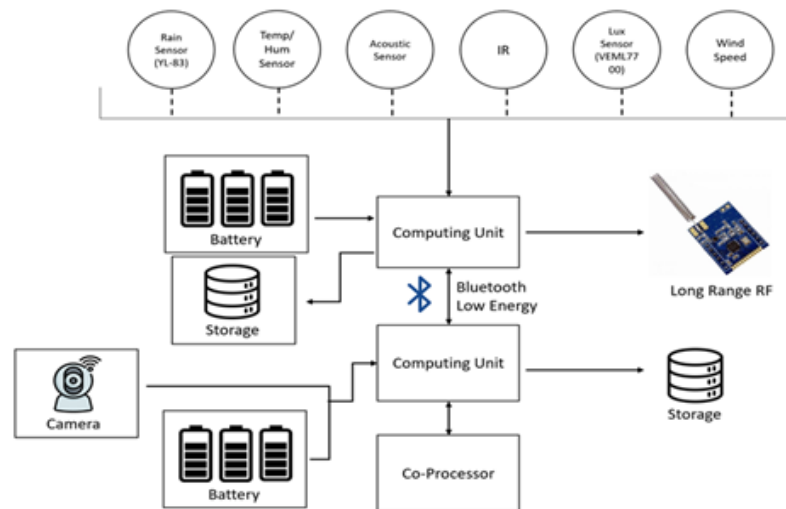


Figure 5. Sensor and Vision Architecture [16]

Apart from acoustic sensors, other sensors used include Lux sensors or light sensors, temperature, humidity, infrared (IR), wind speed, and rain. Data from the various sensors used will be forwarded to the computing unit to process the data obtained to become information. Later the energy used for the sensor node will be sourced from the battery and there is local storage to store backup data and to communicate with other gateways using long-range RF. Meanwhile, the Computer Vision Node (CV) will be placed near or around the sensor to strengthen the information obtained. The camera used will also be based on machine learning that has been developed previously. The working concept of the camera is that it will recognize certain objects, especially humans and the movement of an object based on heat images and process this data so that it can become useful information.

The data is collected periodically through drone patrols and stored in the cloud. Meanwhile, human intelligence collects data through direct observation obtained either through land patrols, community information, or intelligence information related to operations. From the data that has been collected, it will be processed using machine learning to study patterns of criminal group activity. The machine learning method used adapts and combines several previous research concepts. One of them is in terms of predicting the movement of living things based on recurrent neural networks (RNN) [17]. This method will later be readjusted regarding the training data used

in order to provide optimal results. A flowchart related to movement prediction based on the RNN can be seen in Figure 6.

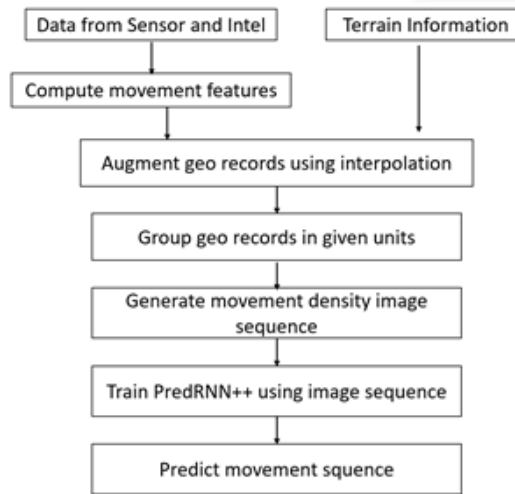


Figure 6. Overall Flow of Movement Prediction [17]

Figure 6 illustrates the directional movement prediction process. Initially, data encompassing the spatiotemporal aspects of enemy movements, including intelligence inputs, sensor readings, and terrain information, is gathered and scrutinized. To refine the movement patterns, a random forest interpolation is conducted, treating the collected data as independent feature values. Subsequently, the geographical records are evenly partitioned, leading to the generation of a movement density sequence that signifies the valid scope of enemy movement. For the construction of a prediction model, a predictive Recurrent Neural Network (RNN) is trained utilizing these movement density sequences. Finally, the predictive model's performance is assessed through various accuracy metrics, and the results of the predictions are visually researched.

In addition to predicting movement, previous research adapted in this design is the ability to recognize suspicious activity based on images recorded on the camera [18]. In general, the steps in identifying suspicious activity include starting from detecting foreground objects, detecting objects that are the focus of tracking, then proceed with extracting features as well as classification, and the last stage is analyzing habits and identifying habits. The working diagram can be seen in Figure 7.

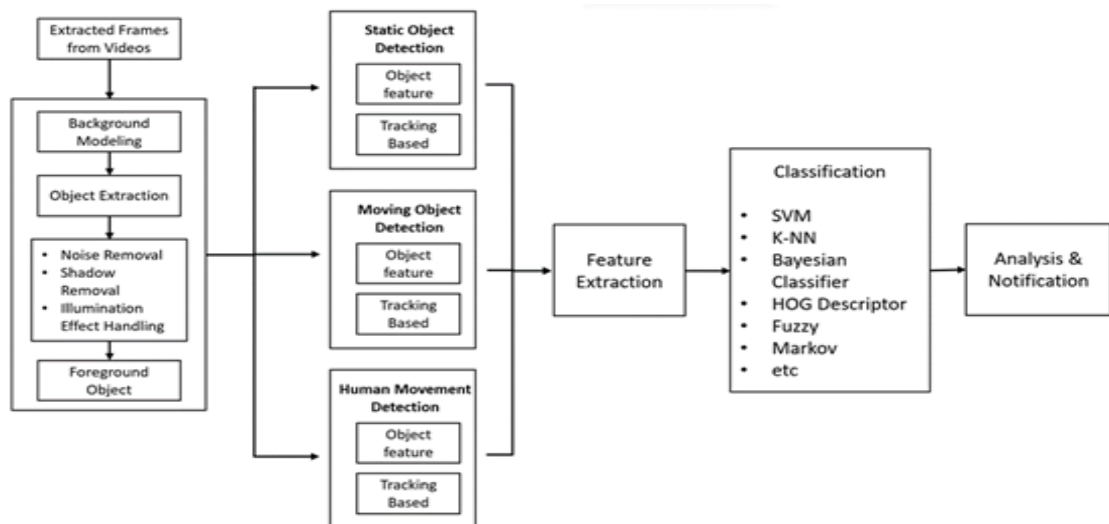


Figure 7. General Framework for Object Detection [18]

The data that has been collected and processed using machine learning will be visualized in GIS. Figure 8 shows an overview of ISR implementation in GIS. From the Figure 8, it can be seen that the sensor is able to detect the direction of the shot and detect suspicious movements. In addition, GIS can display predictions of the next opponent's movements based on consideration of the data they have. So that the integration of this information fulfills aspects of COP implementation, including connectivity between technologies, real-time data, common perceptions, increasing situational awareness, and optimizing decisions and responses for policy makers.

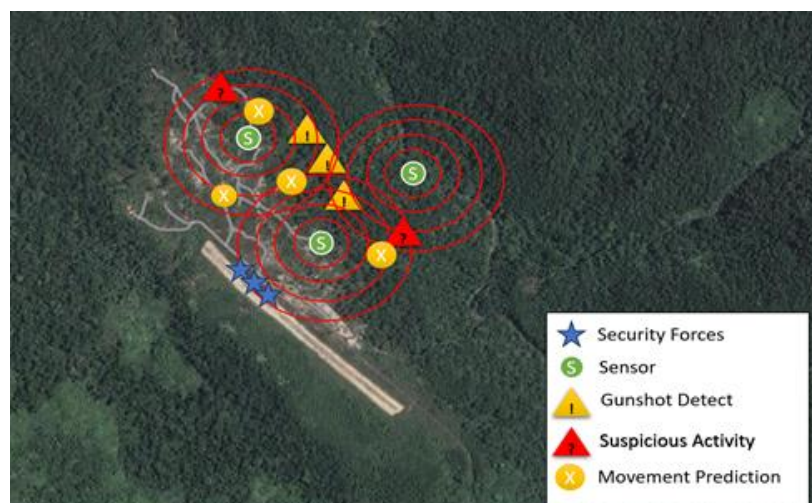


Figure 8. System Implementation Concept

With the implementation of the ISR concept in GIS, it is hoped that it will also be able to increase effectiveness in securing an area by utilizing the resources it has. In addition, the existence of a Common Operating Picture will build a common perception for command or policy holders so that it can facilitate coordination between units, both at the regional and central levels and can provide appropriate policies to support operations.

4. CONCLUSION

This study aims to create a geographic information system development design concept based on the implementation of the ISR concept. This is done by integrating existing information both through human intelligence and data sourced from sensors. The information obtained from this process will be stored in the cloud and processed using machine learning to study the patterns of criminal group activity and visualized in GIS. Research on the development of geographic information systems based on the implementation of the ISR concept has great potential in increasing the effectiveness of the security of an area. However, there are some suggestions that can be developed in further research. Among other things, it is necessary to conduct further studies to obtain high data accuracy by expanding the range of sensors and technology used to collect data. In addition, the system can be integrated with other platforms such as smartphone applications or other applications that security officers are familiar with. Another thing that can be done is to develop appropriate machine learning algorithms that can help improve prediction accuracy and optimize response time. Furthermore, an evaluation of the effectiveness of the system can be carried out by comparing data before and after system implementation and looking at significant changes in crime rates and a social impact analysis needs to be considered to ensure that the system is not only effective in reducing crime rates, but also does not have an adverse impact on society. By developing these suggestions, it is expected to increase the effectiveness of geographic information systems.

REFERENCES

- [1] Patiran, G., Setyabudi, C.M. & Mayastinasari, V., To Win the Heart and Mind The People of Papua: Fungsi dan Peran Brimob dalam Operasi Damai Cartenz 2022, *Jurnal Civic Hukum*, 7(2), pp. 211-223, Nov. 2022. (Journal)
- [2] Antara, Kapolda Papua Minta Warga 6 Daerah Rawan Tidak Gelar Shalat Id di Lapangan Terbuka. *Kompas*. URL: https://regional.kompas.com/read/2023/04/18/150829478/kapolda-papua-minta-warga-6-daerah-rawan-ini-tak-gelar-shalat-id-di?utm_source=Vari_ous&utm_medium=Referral&utm_campaign=Top_Desktop (accessed May. 25, 2023)
- [3] Patiran, G., Setyabudi, C.M. & Mayastinasari, V., Diversification of Functions and Roles of Brimob Police Human Resources in Operation Cartenz 2022 Papua Peace Operation, Master Thesis, School of Strategic and Global Studies, University of Indonesia, West Java, 2022. (Thesis)
- [4] Kim, K., Youn, J., Yoon, S., Kang, J., Kim, K. & Shin, D., Study on Cyber Common Operational Picture Framework for Cyber Situational Awareness, *Applied Sciences*, 13(4): pp. 1-20, Feb. 2023 (Journal)
- [5] Raymond, A., A Common Operating Picture for Air Force Materiel Sustainment: First Steps, ed. 1, RAND Corporation, 2008.
- [6] Li, J., Pei, X., Wang, X., Yao, D., Zhang, Y & Yue, Y., Transportation mode identification with GPS trajectory data and GIS information, *Tsinghua Science and Technology*, 26(4): pp. 403-416, Aug. 2021 (Journal)
- [7] R. Vicen-Bueno and D. Eleftherakis, "ISR sensors to increase the security of underwater communication cables: Case study for deep-water areas," *Global Oceans 2020: Singapore – U.S. Gulf Coast*, Biloxi, MS, USA, 2020, pp. 1-10, doi: 10.1109/IEEECONF38699.2020.9389137.
- [8] R. Vicen-Bueno, G. Cimino, D. Cecchi and B. Garau, "Live tasking / command and control (C2) of ISR unmanned underwater gliders from remote operational sites," *OCEANS 2019 MTS/IEEE SEATTLE*, Seattle, WA, USA, 2019, pp. 1-12, doi: 10.23919/OCEANS40490.2019.8962780.

- [9] Mukhtadi. Government Strategies In Managing Papua Separatist Movement and Its Implications on Defense Diplomacy. *Jurnal Diplomasi Pertahanan*. 2021;7(2): 85-94.
- [10] Butcher, Craig & Schutte, Cornelius. (2015). Technology Selection Framework For Port Development Projects. In *Proceedings of the International Association for Management of Technology*, Cape Town, 2015 : 1064-1081.
- [11] M. Brandfass, A. Dallinger and K. Weidmann, "Modular, Scalable Multifunction Airborne Radar Systems for High Performance ISR Applications," 2018 19th International Radar Symposium (IRS), Bonn, Germany, 2018, pp. 1-10, doi: 10.23919/IRS.2018.8447951.
- [12] C. Yu and J. Lee, "Mission Control Software Architecture for ISR-type Unmanned Surface Vehicle," 2019 19th International Conference on Control, Automation and Systems (ICCAS), Jeju, Korea (South), 2019, pp. 675-677, doi: 10.23919/ICCAS47443.2019.8971451.
- [13] S. Puuska, et al, "Integrated platform for critical infrastructure analysis and common operating picture solutions," 2017 IEEE International Symposium on Technologies for Homeland Security (HST), Waltham, MA, USA, 2017, pp. 1-6, doi: 10.1109/THS.2017.8093737.
- [14] R. J. Hall, "A geocast-based algorithm for a field common operating picture," MILCOM 2012 - 2012 IEEE Military Communications Conference, Orlando, FL, USA, 2012, pp. 1-6, doi: 10.1109/MILCOM.2012.6415848.
- [15] A. Novák and L. Buřita, "Business Intelligence and ISR Data Processing," 2019 International Conference on Military Technologies (ICMT), Brno, Czech Republic, 2019, pp. 1-8, doi: 10.1109/MILTECHS.2019.8870135.
- [16] Rajesh S., et al. Forest 4.0: Digitalization of Forest Using the Internet of Things (IoT). *Journal of King Saud University – Computer and Information Sciences*. 2021;34(8): 5587-5601. <https://doi.org/10.1016/j.jksuci.2021.02.009>.
- [17] Rew J, Park S, Cho Y, Jung S, Hwang E. Animal Movement Prediction Based on Predictive Recurrent Neural Network. *Sensors*. 2019; 19(20):4411. <https://doi.org/10.3390/s19204411>.
- [18] Tripathi, R.K., Jalal, A.S. & Agrawal, S.C. Suspicious human activity recognition: a review. *Artificial Intelligence Review*. 2018;50: 283–339. <https://doi.org/10.1007/s10462-017-9545-7>.