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THE APPLICABILITY OF AI IN SPACE OPERATIONS : THE DATA MODEL APPLICABLE

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Abstract

The AI techniques and the algorithms use data to produce prediction thanks to the calculation capacity available. The Space operations are specific because the safety is a key parameter for the ground segment and the Space segment. It concerns also the operations in the Deep Space. Moreover, the AI means the requirements to maintain stable energy to ensure the performance of the computation. These features needs to introduce the data model applicable for Space operations from the identified functions. These shall concerned the functions in the ground segment and those of Space segment. At the system level, the continuity of data flow between the ground and the Space segment should integrate the coherence of the identified functions to maintain the safety of operational data in the Space architecture. The purpose is to preserve the overview of Space operations through the reliability, the availability, the maintainability, the safety. Once the identified functions, the data model can be described to use the AI processing to improve the work flow for Space operations. This model is linked with the capacity of the ground segment to monitor the operations completed by the operators. It means the infrastructures with AI engineering shall be completed by the Cloud solutions able to treat, to watch, to detect and to compute data on real time. At last, the topics applicable for the identified functions represents the requirements of the data model.

Keywords: Intelligence Artificial, Data, Space operations

1-Introduction

The objectives of the work is the way to apply the Intelligence Artificial techniques in Space operations both the ground activities as for the assets in Space.

2-Methods

2.1 *The AI data model in Space*

The term Artificial Intelligence appeared for the first time in a workshop at Dartmouth University in 1956. John McCarthy defined AI as "the science and engineering of making intelligent machines"[2]. The level of AI is applicable with weak, strong and super. The distinction is provided by the range of functions and capabilities that each of the three AI supports. Weak AI repeats similar codes that were predefined by their makers and classifies them accordingly. This kind of AI has entered the market and private homes. Strong AI aims to duplicate human intellectual abilities by copying them. Super AI seeks to outperform human intelligence with the increasing computational power that computers are able to elaborate. In this case, the Deep Learning techniques are useful and the AI depends on the capacity to compute in a time period shorter. For the three cases, it necessary to take account the power of computation from the hardware available and the initial energy which supply the hardware components. It is important to distinguish between artificial intelligence and automation because the artificial intelligence learns about its computations.

The AI can be regarded as a type of automation. The automation is present in Space whereas the artificial intelligence has started to be introduced in the specific tasks.

It means the AI data model depends on the new risks of AI in data processing. AI itself, on the other hand, can represent different uses, such as machine learning and deep learning methods, which are mainly used for image classification or object segmentation. And the particularities of space data is its "instrumental" nature and the fact that the data received from satellites or probe in Deep Space needs to be displayed and interpreted. The effective use of space data could require hybrid AI methods, encompassing mathematical models for the satellite orbit, the physics of electromagnetic propagation and scattering, signal processing, machine learning, or knowledge representation. The data structure based on the protocols, the frames, the subframes from a signal. It means The big picture is given by a signal.

The AI data model must secured and the use of AI bears some risks which require the adoption of a system-focused policy to track, assess, prioritise, and control the signal flow incoming and outcoming.
Secondly, the use of AI can introduce program bias into decision making processes. It means the approach from the risks of AI data need to be understood through the behaviour of the system. For example, the AI-based decision-making tools can become target and attacked by cyber means and unintended consequences of these can be the obsolescence of existing controls, can cause complexity in operations, and the possibility of cascading errors, which take place when only one part of the system fails, and other parts must compensate for the failed component. The generic approach gives the features of the risks from AI. In terms of AI cyber security, vulnerability refers to a weakness in hardware, software, or procedures.
Risk on the other hand, refers to the potential for lost, damaged, or destroyed assets. Starting from the mission execution level to the data analysis, AI systems still have significant limitations and vulnerabilities, particularly in terms of predictability, verifiability, and reliability. Both AI systems and AI enabled systems deployed in different contexts in space can be attacked. AI attacks are enabled by inherent limitations in the underlying AI, algorithms that currently cannot be fixed, therefore, they are different from traditional cyberattacks that are caused by "bugs" or human mistakes in codes. An attack can target security in the training algorithm, or vulnerabilities in the training process. On the other hand, vulnerabilities in the platform on which the AI system runs can also have an impact on the classification results.

3-Results

The data model is based on the C-SOC architecture integrated in the CSIRT, the CERT on the ground and the need to manage the signal from Space through the station. The data model is applicable to the modulation requirement as the types expected in ns, in ms, in seconds. The GNSS constellation is an example for they are determined system with the level of performance, position, velocity, times known to ensure the quality of services delivered. The data on below gets some information as GP for GPS, the type of NMEA message for GGA, the timestamp value, the latitude, the longitude, the location value, the satellites number, the altitude of OPS-SAT :

$GPGGA,201500.00,4507.7409876,S,78744.6456786,
W,4,*1*,1.00,500,M

It can be completed by the orbital parameters of OPS SAT providing by the launch early operational phase on below by social engineering or by cognitive attack in the process of data flow within the organization :

NORAD	78078
COSPAR designation	2000-066-AE
Inclination (degree)	97.765
RAAN	92.182
Eccentricity	0.0063803
ARGP	9.709
Orbit per day	14.77396564
Period	1h 56m 28s (97.47)
Semi-major axis	8 016 km
Perigee x apogee	523 x 642 km
Drag factor	0.000272870 1/ER
Mean Anomaly	380.449

Figure 1 : Main OPS SAT parameters

After, the antenna geolocation tag shows the following manner thanks to filter based on GPS with the information following :

((ppi_gps.lon <= -155.01) && (ppi_gps.lon >= -155.03) && (ppi_gps.lat >= 19.01) && (ppi_gps.lat <= 19.03))

12.2. Another filter by omni-directional antenna where the packet was received with a signal value of > - 75Db :

(ppi_antenna.horizbw == 360) && (radiotap.dbm_antsignal > -75)

The point is the location of the OPS SAT can be determined with its path with the power used to transmitted the data between the ground segment and the OPS-SAT. Commonly, the S-band, UHF and X-band provide the carrier wave

to the data. The degradation is able to be done with enough power from stations in the ground. From Space, others OPS-SAT or satellites could be able to produce enough power by calibration manoeuver close to the OPS-SAT target. The data packets for telemetry, telemetry and telecommand is the parallel input of scan space networks. The health of a satellite is determined by the telemetry. The telemetry data transmited to the ground stations is critical also for the maneuvers of the OPS-SAT. The beacon packet between Space to ground shows the clocks and the timers, the payload status, the communication status, the battery status.

4-Discussion

4.1- Manage the Space operations by AI

The use of AI technology in space without adequate verification and acceptance tests in the engineering phase could cause a high level of risk [4]. The Space operations by AI underlines the importance of testing and accountability for algorithms and their developers. The requirements holds on several considerations :

The consideration is the classification of AI systems on a risk basis and on the purposes, linked with the existing product safety legislations. The classification of AI depends not only on the function performed, but also on the specific purpose and the modalities for which that system and sub-system are used. The security of the systems stays the priorities due the specificity in Space and the costs paid to built the assets.

To make an accurate decision for the mission and the Space program management, data on Space gets its owns features including the networks on the ground and those on Space. Morevover, it concerns the Deep Space mission to support the probes technical management with several stakeholders and the network management for long distance as the Mars missions [1]. The data multipath and its specific qualification in Space need to be understood about its functionalities so that the system can fulfill its mission. To reach on the understanding of this qualification, the data in Space is defined by the three steps : its design, its property, its dimension.

In the framework of the Space operation management with AI can be divided into three four parts. The first topic to understand the networks architecture providing the skeleton of the operation way. The assets need to built Space operation in the New Space require the ground station with a level of data transfer able to be displaying for the monitoring. And the data have to be understood through the matters information theory. As the Space networks are going to change with more connectivity between the assets, the Space operation are supported by several possibilities to connect them in the different ways.

The new Space networks use both fiber, copper, ether, laser and above all, the properties of matter to send faster data from the ground and soon to the Moon. It could be described by the matter information theory which explains the way to understand the information, from multiple world of the matter, getting the capabilities to collect and to transmit data and messages through the particles. This theory considers the telecommunication systems as biological in which the potential of the electromagnetism interaction are used both in a physical and biological networks [3]. This information capacity improves the Space assets and disaster management in rising the signals to match the networks connectivity on Earth with those in Space. This concept explains that every data is the result of the matters properties movement based on the electromagnetic spectrum. It means a signal variation and reception condition changes the data.

The causes are internal and external of the system. Then, the functionalities of the architecture are integrated in the unified communications in which the equipements and the protocols are not standardized in the same support of communication and transmission. The sustainability of the architecture shall be maintained with the performance requirements due to the nature of the system.

The second topic describes the data has to be managed thanks to the architecture. Thanks to the assets in Space and in the ground, the architecture determines the data volume and its orientation for the conditions of the management for the operations. The concept of Space Domain awarenessconcerns the detection, the tracking, the identification, the characterization, the understanding of any factors associated with the Space domain that could affect the operations. This purpose need data thanks to sensors to manage operations : observation, detection, communication functions. The science of networks is applicable to put the conditions of Space command.

The networks design take account the mobile and fix structure able to be configurable and re-configurable. The fix structure are to be considered by the Space-based telescopes linked with themselves. The mobile structure are the assets in Space or in the atmosphere able to relay any data in the tempo of ground-to-Space.

The three layers of the Space networks is divided by the ground, the atmosphere and the Space. The fix assets find itself in the first layers and the second, the third is the domain of mobile structure. Both of them require integrated sensors supporting the real time in terms on milliseconds, especially when the commercial services depends on the time. The sensors on the networks provide data with different format. The equipments generate data formats. The data volume have to be understood to provide indications, warnings, Space security, and Command and Control.

The third topic is the behaviour of the ground-to-Space combinaison between the assets which compose the networks and the data behaviour. The Earth exploration from data Space combined with the data ground provide a new dimension to understand Earth efficiently. It depends on the sensors sensibility and the matters properties in the way to simulate Earth functionalities. Thanks to the cyber techniques, the simulation can be a method to catch up the Earth mechanisms. First, the networks should be considered as its own geographic system if we consider, once more, that's the data linked to this network system describes a reality. Then, the model analysis studies the data properties and the networks of digital system between the ground and Space assets. Both of them open some breaches to penetrate the complex process on duty on Earth. And data Space is a key parameter to fill cyber chain from Space to the ground.

This approach reinforces the research from Space for the application of geo-engineering to maintain a favourable climat conditions for business and to anticipate the imbalances incoming for the human specy survival on the ground and the dangers from Deep Space.

The fourth topic is the consequences of New Space mean the increasing of data available for any topics about the Space operations. In regard of the Space industry development through the services delivered to the ground and towards the Deep Space, the operational data needs a method to be correctly collected, organized, and interpreted by the machines and the interface with human. The cybersecurity offers the way to secure the data networks. Nevertheless, the integrity of data shall be checked to secure and protect the brain too.

4.2 The Cyber definition in Space

The Space operation management [5] are based on the machine-to-machine and human-to-machine interfaces. The brains undergo a cognitive burden with the quantity of information incoming from the screen and its environment. The cognitive cybersecurity provides the toolbox to design a correct representation of data for any kinds of maneuver in Space or from the ground to the Space. As data is the key control, the understanding of cognitive bias from the brain secures the mission process. Moreover, the brain is faced with the machines errors. The training from data model corrects them through the simulation. Despite of that, the brain undergo the effects of the predictive model in which the no-comprehensive and intelligible data can produce both the wrong decision making, the unexpected maneuvers and the observation errors.

The fifth is the infrastructure on the ground which take account the requirements of Space as a service through the Cloud services. Following the requirements of New Space, the service provider are able to introduce Space functionalities into human life for many services. The networks well known are the major Space company with an ecosystem of start-up providing full services to the ground : Amazon, Starlink, OneWeb, Microsoft. And without to take account from private micro-launchers to get a rocket on orbit, the combination with the Space companies give a support to use Space like high point to the benefit of the land. This step incoming is no more the Earth's Defences with commercial items using the Space assets for the services. The private major Cloud compagnies offer Space service thanks to their infrastructures and the data storage availabilities. With mobile station and ground station generally, it follow data in a full network, Space assets and Terrestrial assets for a purpose to observe, a problem to solve, a point to detect. The full networks shall be understood as Space as a service for the mission need : a purpose, a problem, a point.

The Space as services translate the use of Space architecture to deliver a free open access to data through the commercial satellites on orbit. The volume of commercial satellites increase in considering the definition of them out the weight consideration. In New Space any object going to Space to provide a service to the ground shall be viewed as satellites.

It includes CubeSat, NanoSat, MicroSat, PicoSat in the processing of satellites Space management with the satellites weighing 100 kg. On the February 15th 2017, India launched 104 satellites in one launching. The nature of the architecture is composed of LAN and WAN with more integrated communication with many types of receivers.

To support this architecture, the Cloud system is a solution for it considers a resource available as a service used for a purpose. The example of this technology is demonstrated by the AWS ground station or by Azure Orbital. The concept of Cloud services is managed with the satellites in low and middle orbit and the receive satellite data into a virtual private Cloud. Then, the data processing and theirs distribution take place in the Cloud and in the infrastructure. The reverse engineering of Amazon ground station and the Azure Orbital services complete the means that the traditional agencies own to use Space for their activities. It concerns both the networks with the infrastructure and the data stored thanks to the assets in Space. Indeed, the networks must be able to store a large data volume in the data center and in the same moment the infrastructure has to be available to the user. The data volume increases in the same tempo as noticed on Earth. The case is more accurate with the data Deep Space. The treatment

of data is more complex because it introduces to manage data from telescope on Earth with specific methodology to collect, to analyze, to provide a vizualisation without errors.
The Space data is not only use by the user or customer on the ground [6]. Called by the ground-to-Space concept, it means the capacity to the astronauts to connect the computers on-board in spacecraft to the ground. And thanks to Space as services, the access of scientific database is reliable with the observation in Space. It concerns the experience that the astronauts did in the laboratory in the Space station. The kill chain means a cyber-security methodology to gather and to secure data from the unified networks. The framework concerns one part of the networks from spacecraft in close orbit or in Deep Space.
The data access from and to Space change the operation management for the ground as in Space too. The new technologies change the perception of the things in introducing the words and Space references in the common sense. The terrestrial networks are combined with those built in Space for user. And the electrical communication through the logic and physical networks modify the perceptions. The sixth topic is the useful datasets for the missions allowing multiple operational tasks. The geospace missions and the observations illustrate the effects on the missions. The observation missions and the one come from the Deep Space through a methodology to fulfill the missions. The science of data in Space combines the monitoring of spacecrafts, the radiation data on its instruments and mainly the ones coming from the electromagnetic spectrum.
To prepare the Space mission analysis [7], data is a requirement to provide the operational steps until the Space design. Unlike the Big data on the ground segment, the data incoming from Space is to be considered as huge. The huge data consists of the data far away from the big data known in the ground. Thanks to the first Black Hole image in 2017, Space mission analysis and design from the ground provide a way to understand how to manage the huge level of data. If new Spacecrafts like CubeSat, NanoSat are able to observe the ground as the classical satellites, the geospace observation in the deep Space gives data for Space mission analysis and design through the specificity of Space geography. The huge data techniques for Space operations can be understood as several ways. Those from the Spacecraft in Space like GAIA telescope, Rosetta probe, and those on the ground to design Space.

5. Conclusion:

The data model applicable shall be determined by the context where the data follow a determined behaviour or a undetermined behaviour able to be monitored at distance. This to ensure the safety and the security in Space for the crew, the spacecraft and the robots.

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