Analytical games to support interoperability by design: a case study on reliability impact on human Situational Assessment

Francesca de Rosa[1], Anne-Laure Jousselme[2], Alessandro De Gloria[3], Mathias Anneken[4]
[1] Ms., NATO STO Centre for Maritime Research and Experimentation, La Spezia, Italy
[2] Dr, NATO STO Centre for Maritime Research and Experimentation, La Spezia, Italy
[3] Prof., University of Genoa, Genoa, Italy
[4] Mr., Fraunhofer IOSB, Karlsruhe, Germany

Abstract — This paper illustrates an example on how analytical games could support interoperability by design and more specifically semantic interoperability. We present the case study of the Reliability Game, which aims at characterising the impact of source factors on human Situational Assessment. We moreover show how the data collected through this method can be directly used to refine the information system design.

1 Introduction

The concept of interoperability refers to the capability of systems to exchange information. Several layers or factors of interoperability exist. The highest level is referred to as semantic interoperability, which relates to the ability to preserve the format and meaning of exchanged data and information [1]. Information systems are increasingly adopted both in the military and civilian domains. The ability of those systems to integrate and correlate data and information deriving from heterogeneous sources, differing both in nature and quality and with varying uncertainty is critical to enhance the Situation Awareness and to properly support human decision making. To ensure system interoperability, standardisation should occur also with respect to uncertainty representation and to uncertainty communication across the wide variety of sources. In this work we will show an example on how analytical games could support semantic interoperability by design by presenting the case study of the Reliability Game.

2 Analytical games

The term *analytical game* encompasses both analytical wargames and data-exchange serious games. The first category of games, designed for research, points to "warfare model[s] or simulation[s] whose operation does not involve the activities of actual military forces, and whose sequence of events affects and is, in turn, affected by the decisions made by players representing the opposing sides" [2]. The latter, instead, refers to a broader category of games which are developed not primarily for entertainment but rather for researching a specific topic [3].

The Reliability Game [4-5] is one of the analytical games the authors developed to experiment with information dimensions impact on Situational Assessment and related Situational Awareness. More specifically, this game has been developed to investigate source factors impact on Situational Assessment.

3 Case Study: the Reliability Game

3.1 Motivation

An interesting challenge in multi-source information fusion systems is the proper handling of source quality. In fact, the mathematical frameworks of uncertain reasoning allow accounting for source quality through the mediating factor of *source reliability*. However, to take advantage of such instruments in the systems, research is still needed to understand which the reliability dimensions to be communicated are and how they are interpreted across different domains and languages.

3.2 The Reliability Game

In response to this challenge the Reliability Game has been designed. This game enables the recording and mathematical characterization of players' belief changes, while assessing incoming information with respect to a situation of interest. Those changes are captured by means of a specific game board and cards. Such cards are used to provide new information which the player has to position on the triangle on the board. The resulting card position reflects the weight of belief that the information provides toward the mutually exclusive and collectively exhaustive hypotheses. Each game session is divided into four rounds, during which a set of eleven cards is sequentially provided to the player, displaying information about the situation. The rounds differ in the meta-information displayed on the cards (i.e. source type and the source quality). Although other frameworks can be considered, the data collected has been modelled within the Bayesian framework. The results of this modelling effort can be used to drive the design of information fusion algorithms, such as

the MARISA Multi-Source Dynamic Bayesian Network for Behavioural Analysis Service (here after referred to as MSDBN) [6].

3.3 MARISA Dynamic Bayesian Network

The MSDBN is one of the fusion services developed within the Maritime Integrated Surveillance Awareness (MARISA) project, which is a European Commission founded project which aims at providing improved situational awareness through the provision of a toolkit of information fusion services.

More specifically, the MSDBN is a graphical representation of a Bayesian reasoning that aims at supporting anomaly detection tasks. The proposed algorithm presents a hierarchical layered structure, composed by a Situational Layer and a Reporting Layer. The first layer is used to model the situation, while the second one is used to enter evidence regarding the situation, accounting for sources factors (i.e. reliability, source type) [7]. In a first set of experiments with the Reliability Game we observed how source meta-knowledge influences the Situational Assessment and such results can be directly incorporated into the design of the MSDBN Reporting Layer.

4 Conclusions

The proposed work shows one example on how data collected through games can be used in the design of algorithms. More in general, analytical games could help understanding how to properly encode, transmit and decode information between systems in multi-cultural environments. Ultimately, this would impact not only algorithms, but also data-models and communication standards. Therefore, analytical game could be considered a powerful tool to support system design and more specifically the semantic interoperability challenge.

Acknowledgements

This work has been supported by the MARISA project. MARISA European research project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement no. 740698.

References

[1] European Interoperability Framework – Implementation Strategy, TEN/635-EESC-2017

[2] P. P. Perla and E. D. McGrady, Naval War College Review, **64,** 3 (2011)

[3] D. Djaouti, J. Alvarez, J.-P. Jessel, Classifying serious games: the G/P/S model, *Handbook of Research on Improving Learning and Motivation through Educational Games: Multidisciplinary Approaches*, **1**, 118–136 (2011).

[4] F. de Rosa, A.-L. Jousselme, A. De Gloria, Reliability Game for Source Factors and Situational Awareness Experimentation, Int. J. of Serious Games, **5**(2), 45 – 64 (2018)

[5] F. de Rosa, A.-L. Jousselme, A. De Gloria, Gamified Approach in the Context of Situational Assessment: a Comparison of Human Factors Methods, *Advances in Artificial Intelligence, Software and Systems Engineering, Proceedings of the 9th Int. Conference on Applied Human Factors and Ergonomics*, Springer (2018)

[6] M. Anneken, F. de Rosa, A.-L. Jousselme, S. Robert, Modelling Dynamic Bayesian Networks to Identify Suspicious Behaviour, *Proceedings of the Maritime Big Data Workshop*, La Spezia (2018)

[7] F. de Rosa, N. Ben Abdallah, A.-L. Jousselme, M. Anneken, Source quality handling in fusion systems: a Bayesian perspective, *Proceedings of the Maritime Big Data Workshop*, La Spezia (2018)

Author/Speaker Biographies

Francesca de Rosa is a scientist at the NATO Centre for Maritime Research and Experimentation. She holds a MSc in Hydraulic Engineering and she is currently a PhD candidate in Interactive Cognitive Environments. Her main research interests include applied human factors, wargames and Maritime Situational Awareness.

Anne-Laure Jousselme is a senior scientist with the NATO Centre for Maritime Research and Experimentation where she conducts research on Maritime Situation Awareness, information fusion and reasoning under uncertainty. She sits on the Boards of Directors of the International Society of Information Fusion and Belief Functions and Applications Society.

Alessandro De Gloria is full professor in electronics engineering at the University of Genoa. He currently teaches Computer Games and Simulation. He is member Editor of the International Journal of Serious Games. His main research interests concern Embedded Systems, Human-Computer Interaction and Serious Games.

Mathias Anneken received his Master degree in Electrical Engineering and Information Technology in 2014. He joined the Fraunhofer IOSB in 2014 and is currently working towards his PhD at the Karlsruhe Institute of Technology. His research includes machine learning and anomaly detection in the maritime domain.