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Review Report

of Marcin Lenart's PhD Thesis

Sensor Information Scoring for Decision-Aid Systems in Railway Domain.

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1. The Context and the Scope of the Thesis

We live in the age of information and have petabytes of data for our disposal. Therefore, the quality of data and information is crucial. The assessment of the information quality is highly subjective, and it is hard to establish quality criteria. The main goal of the thesis is creating an information scoring methodology without expert knowledge.

2. Layout and Content of the Thesis

Marcin Lenart's thesis consists of seven chapters and a list of references, and it has 129 pages.

The first chapter contains an introduction to the problem and its genesis. The Author sets goals and provides a short description of the thesis structure.

Chapter 2 presents basic definitions and ideas concerning data and information. It explains the distinction between data and information concepts in the latter having source and spatiotemporal context. It provides a broad literature survey.

Chapter 3 describes the ReCLiC model proposed by the Author. The model comprises Reliability, Competence, Likelihood and Credibility and the output is trust as a measure of the information quality. Section 3.1 defines general assumptions of the model, namely to use as broad range of sensors as possible, not relying on the ground truth, possible independence on meta-information. It discusses types of input information and two types of graphs of input meta-

information: State transition graph and Network of sensors. The ReCLiC model in its general form is proposed in Section 3.2.

In the absence of meta-information from an expert that would allow the creation of a state transition graph, the system can create a graph from all possible data. To limit the size of the automatically created graph, the system has the option of entering a threshold.

The first component of information evaluation is reliability, which assesses whether a source can provide reliable data. Reliability is a function of a set of sensors, messages produced by them regardless of the subject, and erroneous messages. The next component is Competence, which is a function of a set of sensors, themes, time, time window and errors. The next component is Likelihood, which is a function of sensors, themes. The next component is Credibility, which defines the convergence of information with other sources. By aggregating these components, a final trust is created.

In Chapter 4 the ReCLiC model is implemented in scoring signals from axle counters. The system is checked on the MoTRicS2015 dataset collected in five train stations in Poland in about one year. The system collects data from axle counters and data points, point machines, signals, power supplies and data loggers. In the chapter the system is implemented for one train station, modeling its network of sensors. The sensors detect passing the train through track sections. State transition graph for Likelihood was generated from data and the second one by a domain expert. The Author noticed the difference between them and used the data-driven one in the system, and expert-generated as an additional source. Very general formulas for Reliability (3.1) and Competence (3.2) are adapted to the axle counter application. Likelihood is computed by the general formula with the data-generated state transition graph. Credibility is computed with an aggregation chosen especially for this particular case. The final Trust is determined by the compromise aggregation.

Chapter 5 checks the model on simulated data. The main problem in assessing information produced by measuring devices is the effective acquisition of previously assessed data that could be used to learn a selected model based on machine learning. In particular, an expert assessment of information in the range <0.1> is not possible from the level of an expert who could prepare such data. Since in most cases, such data is even obtainable, the REclic model performs information evaluation without using any reference data. I understand that the lack of reference data prevents the use of typical machine learning systems. The synthetic data in Chapter 5 is intended to replace the typical testing of a new model using standard data (which is not available). Through various types of modification on the original data, the Author could implement various types of problems and check the tested model in terms of their detection. In the presented chapter we are dealing with four different simulations that do not specify all possible types of problems that may arise after the implementation of the system and it is possible to add further scenarios which will increase the level of testing. The assessment of the quality of information largely depends on the specific use cases, an advantage of testing by modifying real data is that the data used is the same on which the system under test is to operate. It should be emphasized that the Author, having no real data with an expert assessment, created the data based on the existing data, with a similar distribution. The system is tested on data with noisy data from a single sensor and from a single topic. Moreover, the Author added burst noise

and injected randomly messages. The last subsection of Chapter 5 concerns determining the ReCliC parameters from data, i.e. internal aggregation operator, the weighted average parameter and the length of the time window.

Chapter 6 presents a real-data application of the ReCliC framework. The final trust is visualized in the form a heat map. To visualize sparse railway events, they are aggregated. Such form of visualization allows the system operator to quickly assess the information state.

Chapter 7 concludes the Thesis and sets some directions of possible future work. The possible ideas can be a base for a novel PhD thesis.

In general, the main and original results of the thesis can be summarized as follows:

- Development of the presented methods with an industrial partner.
- In-depth introduction to the topic and the related works.
- Creating a new methodology for Information assessment.
- Real-world application of the proposed methodology in a very demanding area of the railway infrastructure.

These original methods proposed in the work have been published in several scientific articles. The presented material shows that Mr Lenart has achieved the goals of the thesis.

3. Critical Remarks

How did the system is implemented? What was the environment and programing language?

What exactly is the origin of the number of 275 messages on page 109? It seems not to come from any assumptions concerning the ReCLiC system.

What will happen if the railway system fails (there is an anomaly). Will not the ReCLiC system lower the quality (trust) assessment due to the lack of similarity to existing events?

Chapter 4 leaves the impression that the inference system resulting from the train infrastructure strongly depends on the particular field of application (railway). Is it easy to implement the system for other applications? In other words, how much domain knowledge is needed to do so?

Figure 4.1 seems not to be referenced in the text.

The thesis has some typographical and language errors; below there are some examples:

page 22: "fats" instead of "facts"

Figure 4.2: Illustration of the axle counter principle which consists in -> consists of

Figure 4.5.: "Solid red edged are present" – edges?

are present on Figure 4.4 – in Figure

p.82: Such simulated datasets allow to control the type of introduced quality problems, as well as their intensity and distribution. -> allow controlling

They allow to cover a large spectrum -> allow covering

4. Conclusion

Marcin Lenart in his PhD thesis achieved the goals of the dissertation, obtained original scientific results concerning information quality assessment, made an introduction to the state of the art, created a novel ReCLiC model for trust assessment, named after four components Reliability, Competence, Likelihood and Credibility. Moreover, he applied the model in the railway domain.

The reviewed work meets the requirements of the act on the title and academic degrees in the scientific discipline of computer science. I am asking for its acceptance and admission to public defence.