

Poor requirements engineering impacts project outcome

## **Advancing Requirements Engineering by Applying Artificial Intelligence** For faster, better and clearer requirements

**We hear it again and again: Good Requirements Engineering is the foundation of many successful product launches, whilst poor requirements are the cause of many project failures and delayed projects. In today's competitive market environment, this is becoming ever more important. Artificial Intelligence is becoming an important lever in helping companies to improve the authoring of requirements with real-time feedback on the quality.**

A late or failed project can have fatal consequences for the company with respect to image, revenue, etc. With continually more connected products the complexity is ever more increasing, and with this, the data and the requirements grow as well. Fast feedback to whatever we do is becoming ever more critical to remain on track and to pivot if need be. Thus, improving the engineering processes is key to meeting tomorrow's challenges as today's traditional methods have reached the end of their lifecycle.

### **The rationale to improve Requirements Engineering**

Theoretically, it all sounds easy to author correct requirements. There are many guidelines around such as the IncoSE "Guide for Writing Requirements", ISO 15288 or IEEE 29148-2018, many training courses including certifications (for example, refer to those by IREB®) and even more consultants. Still, according to several studies, poor requirements are the major cause for failed projects, soaring costs or delayed launches. This has not really changed in the last decades. The reason may well be that with the introduction of lean and agile practices the methods are getting better and learnings are done, but as data volume and complexity is also increasing, the effect is not seen.

Poor requirements can lead to misunderstanding, unnecessary discussion, false interpretation, all leading to a waste of effort, longer development time and higher cost. By improving the quality and validation of requirements as early as possible (also known as left shift) the positive impact is manifold. Further, if the author can be assisted in quasi real-time during the requirements writing, the effect will be even more positive. This will reduce review time, usually involving many people, and allows these reviews to focus on more important issues, where the power of having various stakeholders is of real value.

With increasing connectedness and complexity, understanding requirements as early as possible will become even more important for speed and focus. The process, however, should flow, as the

danger of too much detail too early on may well also be contra-productive. Organizations need therefore to find ways to assist in improving the quality of their requirements early on, helping to understand and clarify them. This will also help to speed up development and reduce cycle time.

### **Status quo – and why this is part of the problem**

With current solutions the cost to fix software defects rises exponentially with each successive phase of the project life-cycle. There are numerous reasons why they can miss errors, including:

- Rules engines: Rules are good but have their limits. Simple key word searches cannot understand words in context. For example, the word “clear” in following sentence “The GPS system shall provide a clear perspective of the road” is ambiguous, however, in “The GPS System shall clear the display on transition to power off mode” it is not ambiguous.
- Peer review: Peer reviews are excellent, but difficult to enforce across teams and to be effective across the broad scope. It is a manual, tedious task to review long documents – which again are difficult to keep above. Further, you want to optimize the use of your resources on high added value tasks.
- Checklists: Checklists are very useful tools to ensure quality. However, applying them has not been very successful. This may be due to our limited capacity to keep track of all quality indicators as our cognitive span is 7 +/- 2 things. As a reference the Incose “Guide for writing requirements” has about 100 pages and includes many rules. The user may well feel overwhelmed.

### **New approaches applying Artificial Intelligence**

The challenges mentioned manifest that it may be the time for a change in supporting and improving the Requirements Engineering processes. Artificial Intelligence techniques are considered a promising approach to address complex Requirements Engineering problems. Before going into the particulars, let’s first have a look at what Artificial Intelligence is all about.

Artificial Intelligence (AI) is a branch of computer science that deals with the automation of intelligent behavior and machine learning. The term cannot be clearly defined as there is already a lack of a precise definition of “intelligence”. Nevertheless, we can say that AI is what gives machines the power to learn, adapting to new inputs to make better decisions. Machine Learning, a subset of AI, uses computer algorithms to analyze data and make intelligent decisions based on what it has learned. Deep Learning, a part of the broader machine learning methods, in addition, layers algorithms to create artificial neural networks. It allows the algorithm to continuously

learn on the job, from the results, determining if decisions were correct, thus constantly improving the quality and accuracy of the results. Various deep learning architectures exist. Without going into detail, they can, for example, focus on knowledge and understanding as their ultimate goals, or independent learning. They will all get better the more relevant data they are fed with. Further, AI systems learn to know what they know and what they do not know.

### **What can be gained using Artificial Intelligence?**

For businesses, the overarching aim of using AI is to become smarter, faster and securer. Generally, the explosion of data is challenging everyone. AI is predetermined to deal with lots of data. The explosion of data is in addition exponential and as such the knowledge gap is increasing as we humans learn in a more linear way. AI can thus accelerate and augment our capacity to act by injecting knowledge and automation into business processes.

The AI architectures can further be layered in layers, such as general knowledge, industry-specific knowledge and finally customer-specific knowledge in order to maximize the value of the data, but also to allow protecting customer data and apply and make the learning of the algorithms to customer-specific context and DNA. This is very important to deal with issues such as transparency and security which need to be addressed at the enterprise level. As such AI will help business to operate more smoothly and more productively helping to deal with ever more complexity and data.

### **Artificial Intelligence in Requirements Engineering**

AI has the aim to help to automate processes, improve the quality and reduce risk by turning data into insight and models, which can be used to help engineers in mastering their challenges more effectively. In the context of Requirements Engineering AI can be applied in understanding text and thus can help finding deficiencies in requirements. With deep learning and natural language processing (NLP) AI can help understanding the semantics of a language. It can understand processes and, by using semantic concepts, can be applied in many ways, e.g. in the context of requirements quality. With respect to the aforementioned status quo AI can easily apply rules and checks and thus allow to focus review time on important issues, solving and automating many current issues related to poor requirements.

Generally speaking, AI can help in the following areas:

- **Completeness:** Unfinished requirements lead to preventable confusion and delays.
- **Consistency:** The more consistent requirements are the fewer opportunities there are for errors.
- **Accuracy:** Accurate requirements reliably articulate the objectives of stakeholders.

### **Benefits from AI for Requirements Engineering**

The ultimate benefit of AI is in helping to ensure the requirements are written correctly as early as possible based on the data available. This will save effort and time for reviews and false assumptions and misinterpretations. This improved quality will help to focus work, improve the effectivity and time to market. From a company perspective quality checks based on company standards will further ensure alienation within the company fostering the company jargon and DNA.

As such with AI you will turn increased complexity into increased opportunity to reduce risk and defect cost, reduce review time and associated costs, build up a company knowledge base which can be reused. This all helps to share experience and ease and speed up onboarding of new engineers. Of course, the overall benefit of improving the quality and clarity of requirements cannot be underestimated.

Currently, we are seeing that AI is helping with various quality issues, for example with respect to unclear actors or user, compound requirements, escape clauses, missing units, missing tolerances, ambiguity and incomplete requirements. Well-integrated AI can assist the Requirements Engineering by finding issues, scoring the requirements quality to help in prioritizing and provide guidance by clarifying the issues found and supply corrective actions to the engineer, helping to improve his practices. Further, through the continuous interaction the algorithms will learn and as such improve over time becoming more precise in the customers' context.

## Outlook

AI is no longer a nice-to-have, it has become an essential feature of state-of-the-art Requirement Engineering solutions to improve requirements quality early in a project. AI accelerates our capacity to act by injecting knowledge and automation into business processes. Engineering teams can more easily flag poorly written, incomplete, and ambiguous requirements while receiving real-time coaching from the AI on how to improve them.

AI techniques have become more powerful and easier to use over the past years. Integrating AI capability has brought Requirement Engineering to a new level already. However, there is more to come. One of the most difficult aspects of today's, and even more tomorrow's, complex engineering projects is the sheer amount of data that teams are required to manage. As product designs attempt to solve increasingly difficult problems, the result is an explosion of engineering data. In future, the power of AI will reach further dimensions, e.g. in the area of duplicates and conflicting requirements. As in many other areas, AI is definitely changing the way things are done in the product development process. Obviously, a lot of the work that is now performed by way of manual labor will be empowered by intelligent AI algorithms.

Many changes are still to come. Gartner included AI in its top 10 strategic technology trends for 2019. According to Gartner, "every organization should consider the potential impact of AI on its strategy and investigate how this technology can be applied to the organization's business problems. In many ways, eschewing AI exploitation is the same as forgoing the next phase of automation and could place enterprises at a competitive disadvantage."

## Next Step

If you have questions or want more information about solutions addressing this, please contact Philip Zollinger at EVOCEAN. He will be happy to share more information with you.