Inspection 4.0, Synthetic Data and AI - Planning for the Future

Petra Gospodnetic[1], Lovro Bosnar[2], Juraj Fulir[2], Hans Hagen[3]

[1]Image Processing, Fraunhofer ITWM, Germany, [1]Image Processing Department, Fraunhofer ITWM, Germany, [1]Computer Graphics and HCI, RPTU Rheinland-Pfälzische Technische Universität, Germany

Industry 4.0 encourages manufacturing speed, precision and high customization capabilities. As such, it places considerable expectations on the research community to work hard with industry in order to identify challenges and ensure necessary technologies are available and ready to be utilized to address them. Over the recent years we are witnessing significant steps and advancements happening swiftly across various research fields and topics such as artificial intelligence, augmented reality, internet of things or additive manufacturing. Those steps were typically taken in the direction of improving production and logistics processes, while, at the same time, quality inspection has not received the same level of attention. As production lines move forward towards more control, automation and customization; quality inspection systems capable of following the advancements become an apparent issue. How can a highly customizable product be efficiently and consistently inspected? Current quality inspection processes are still frequently performed manually by certified inspectors. Efforts to automate the processes exist and are oriented towards automatic data analysis. However, automation expects the product to be consistent so that the input data behaves as expected. In this case a question which is not discussed frequently enough is – how is the data acquired? How long does it take to establish reliable acquisition processes which can ensure defects are discovered if present? How are inspection systems evaluated? How are they adapted when the inspected product changes? An answer to all those questions is again – an expert. Only way to offer a solution to the above questions in a manner which can follow the automation. Introduction of virtual inspection planning pipeline offers new opportunities for standardization, even for something as challenging as AI. The digital twin of the inspection system described in the inspection plan serves as basis for precise inspection coverage evaluation and rule-based generation of pixel-perfect annotated synthetic datasets. In contrast to synthetic data generation using generative AI, the rule-based nature provides us with possibility to precisely describe the training dataset and quantify the nature and number of possible edge cases used in training. As such, it is of particular importance for NDT community. It opens new doors for using synthetic data as a point-of-control in AI, evaluation of its target domain and enabling the development of truly flexible and robust inspection systems in a controlled manner. Finally, synthetic data is a new opportunity to push the research further in terms of AI testing, validation and certification for NDT. Product quality assurance is a crucial part of every production process. It is about time we start talking what does that mean in context of Industry 4.0 and how to keep the pace with surge of AI driven advancements.