We recently learned about an intriguing joint collaboration between the University of Bologna, the National Institute of Nuclear Physics, Cineca, and the Emilia-Romagna Region with Art-ER, Bonfiglioli and Marposs. The IoTwins project involves big data, artificial intelligence and the internet of things applied to manufacturing and infrastructure, creating models capable of simulating production processes in the laboratory and detecting errors before the production stage. Victoria Hattersley spoke to Gaetano Ciaravella, Strategic Project Manager at Bonfiglioi, to find out more.

Based in the Emilia-Romagna Data Valley as part of the Horizon 2020 programme, IoTwins will experiment with new technologies for the digitisation of industrial processes and products. It will encompass 12 test platforms that will create ‘digital twins’, or virtual copies of industrial processes that will be used to test plants and infrastructure management tools in advance.

In addition to local partners, the project will also include international leading
companies and scientific institutions such as Siemens, the Supercomputing Centre in Barcelona and the Fraunhofer Institute in Munich.

**VH**: Can you tell me a little about the background of the IoTwins project? How important do you think such cross-industry collaborations are to foster innovation and build a more connected world?

**GC**: In Italy, research bodies such as INFN, CNR, ENEA, GARR and CINECA have already implemented big data via high performance computing and e-infrastructures to support major research and academic communities. Most of these Italian high performance and high throughput computing resources are concentrated in the north of Italy, especially in Emilia-Romagna, where they are well integrated into the local knowledge and business systems.

Since 2015, stakeholders involved in supercomputing and big data production and management have engaged in mapping and analysing their potential impact on scientific, social and business domains: thus, a Big Data Association was set up to interconnect and jointly exploit the knowledge, capacities, research and innovation potentials of this community to leverage the effects of actions and investments made so far and to maximise their impacts, locally but also at national, EU and international levels.

On the other side, Bonfiglioli implemented in real applications monitoring systems in which consistent amounts of real data were and are generated.

IoTwins was born within the Big Data Association and Industries, thanks to the joint efforts of the University of Bologna, INFN, Cineca, ART-ER and Bonfiglioli Riduttori, where the use of HPC with big data will enable different and new technologies through specific use cases/testbed.

Therefore IoTwins is the result of a close collaboration among public/private bodies, including academia, industry and government institutions, in synergy with those actions already active in the region for supporting data economy.

Starting with the group of core members cited above, the partnership had been enlarged in order to involve further excellence in scientific research and industrial partners for the deployment of a number of testbeds and find several potential applications.

**VH**: For those who may be less familiar with the concept, can you explain how digital twinning – using big data technologies – can be used to increase the efficiency of industrial processes?

**GC**: **Definition of digital twins.** Digital twins are cyber counterparts of physical systems that try to mimic as much as possible the behaviours of their physical counterparts. Generally speaking, this allows to have a digital ‘copy’ of the managed physical system, with the opportunity of observing it under conditions and input that are not always possible to be provided to the physical counterpart. For instance, we can accelerate what will occur in the real world so to observe rapidly (time acceleration) what will be the future behaviour of the twinned physical system, or we can impose load/stress conditions that are not easy to be obtained in the real world, for example because these conditions are unsafe for a real production environment.
**Digital twins and Big Data.** Building a digital twin that correctly mimics the behaviour of the physical counterpart is a complex, long, and expensive process. In fact, typically this requires modelling the system in the real world via complex models (e.g., systems of equations) and articulated simulations/emulations, requiring deep mechanical, electromagnetic, electronic, and computer engineering competences. In IoTwins, the main guideline is to build digital twins via big data technologies, i.e., via machine learning techniques that are able to automatically build models by learning from the observation of physical counterparts, by exploiting different kinds of learning techniques (e.g., neural networks, reinforcement learning, distributed federated learning, ...). These digital twins automatically determined via big data techniques could also be hybrid, i.e., integrated with the results of analytical modelling and simulation of the physical counterparts. In addition, IoTwins digital twins will executed in a distributed way, partly local to the observed physical counterparts, partly in a remote data centre of cloud/HPC resources.

**Digital twins for industrial processes.** IoTwins primarily targets digital twins for optimising the processes and increasing the efficiency of the manufacturing lines of its industrial partners. Two main sub-areas can be identified: i) improving efficiency by performing predictive/prescriptive diagnostics (e.g., if the digital twin predicts correctly the next fault/malfunctioning and its technical motivations, this info can be used to optimise maintenance processes, to reduce downtime, and to reconfigure the manufacturing line in order to postpone the fault to the optimum time); ii) improving efficiency by minimising product items under a given quality threshold through proper runtime re-configuration of controllable parameters of the manufacturing line (e.g., the digital twin gives us data about how a setting modification under given conditions can affect the final quality of the product, without having to do a real experimentation over the physical system).

**VH:** We are of course particularly interested in the implications of this project for the packaging sector. Can you give me examples of how this project can be / has been applied to improve efficiency along the packaging value chain?

**GC:** For packaging, on the one hand, IoTwins solutions will help to optimise the maintenance processes (in particular by predicting faults in the different stages of the manufacturing lines and allowing prescriptions to postpone faults by regulating speed, pressures, etc.). On the other hand, IoTwins digital twins will be able to predict the quality of packaging products during the production itself, by suggesting how to change manufacturing line settings at runtime in order to maximise the number of produced items that can pass the targeted quality tests. In addition, digital twinning can help a lot in designing and prototyping more rapidly new packaging solutions for the next generation of packaging machines, in particular via hybrid twins, thus helping to increase the competitiveness of the companies that adopt them.

Finally, note that the big data collected for some deployment cases (over some packaging plants) can also be useful to improve the behaviour of the packaging machines for other similar cases, if the digital twin is able to realistically mimic the behaviour of its physical counterpart under different environmental and usage conditions.

**VH:** Given the pressing need to address the ongoing climate crisis, what are the implications of this project from a sustainability perspective?
GC: The fight against climate change requires a change of the system that can only take place through governance that can guide as many communities of innovators as possible, be they researchers, policy makers, entrepreneurs or citizens.

IoTwins will involve a repositioning of the industrial system in Europe and in the world, that for sure will also positively impact the climate crisis.

Optimisation and prevention thanks to the digital twins inside the testbed and within the models that will be generated can contribute in terms of reduction of scraps, in optimisation of energy generated, or energy saved by performing the same tasks.

VH: What are the biggest challenges the project has to overcome? How are these being approached?

GC: IoTwins addresses several state-of-the-art and open challenges, not only technical. First of all, the quality of digital twinning has a strong dependency on the quality of the collected data on which to apply machine learning techniques. And in several industrial environments, the collection of huge amounts of ‘well-curated’ data about the production processes is still an ongoing process. Second, which machine learning techniques to adopt and how to optimise them for the manufacturing industry is still a completely open field in the related literature. Third, in the manufacturing domain, some IoTwins services will have to work under strict latency constraints, for example for allowing the online reconfiguration of production lines in response to an abrupt variation of working conditions and while minimising the defective products.

From the non-technical perspective, IoTwins also aims to open the market of digital twinning to SMEs, which typically do not have enough resources to access complex technologies and solutions in this field. This will be done through the realisation of a platform of common infrastructure and AI services, that will be highly usable, open, portable and cost-effective. Lowering the barriers for SMEs to adopt digital twinning solutions for manufacturing and facility management is central for IoTwins. This is very relevant for Italy and EU, and potentially will open very significant business opportunities for growth.

VH: What comes next for the IoTwins project? How will it be rolled out and are there any further projects in the pipeline?

GC: We are in the first phases of the execution of the IoTwins project. The first necessary steps that we are now undergoing are the collection of curated monitoring data (of sufficient volume and quality) and the collection/merging/elicitation of the functional/non-functional requirements needed in the different pilots of the project. Based on them, the IoTwins platform (distributed cloud continuum layer and AI services layer) will be designed and implemented. Interoperability and openness will be crucial elements that will be considered.

After these first steps we plan to be able to show the effectiveness, efficiency, and advantages of adopting our digital twins in the different IoTwins vertical domains in one year from now, with tangible results that will show the suitability and replicability of the proposed approach.