EngineeringX

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Transforming Systems through Partnership

Royal Academy of Engineering

technopolis group

RIGHT-FIRST-TIME FUSED DEPOSITION FOR HEALTHCARE MANUFACTURING

Lead partner: Dr Wafa AlAlaween, University of Jordan

THE PEOPLE

Dr Wafa AlAlaween, University of Jordan

Professor Mahdi Mahfouf, University of Sheffield

Ahmad Al Soussi, The Printie 3D Company

THE CHALLENGE

Jordan's additive manufacturing sector is new but expected to grow considerably during the next decade. Despite its potential, Jordan relies on imports for medical products and devices such as implants. This is in part due to the high cost of producing medical products using additive manufacturing techniques such as fused deposition modelling (FDM).

FDM is a type of additive manufacturing process that builds parts layer by layer by selectively depositing melted material in a predetermined path. FDM has numerous advantages including being efficient and cost-effective for prototyping and direct digital manufacturing of 3D print end-use parts such as components and products. These advantages have made FDM applicable to the healthcare manufacturing sector.

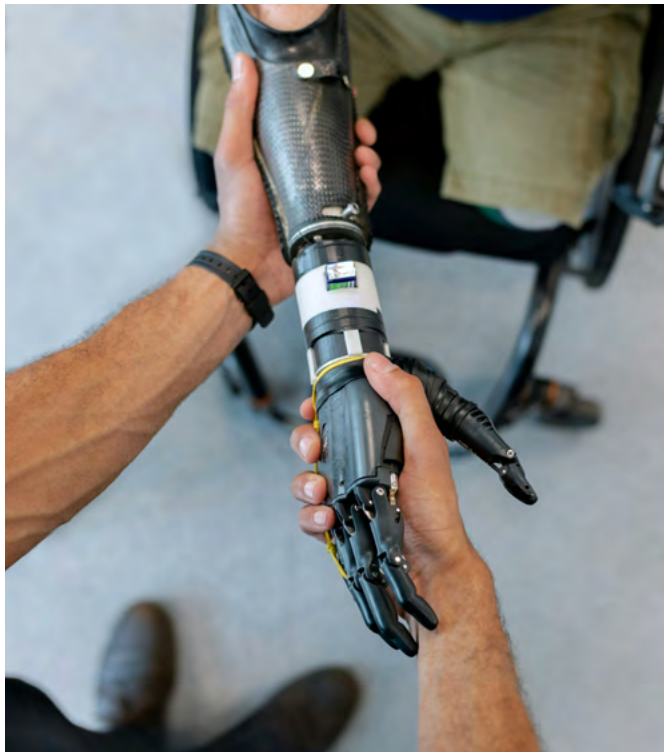
Despite these advantages, the manufacturing process can be challenging. FDM requires iterative design through prototypes, as features do not usually print right the first time. This makes the FDM process to be a costly and time consuming one.

Under the Engineering X's Transforming Systems through Partnerships (TSP) programme, Dr Wafa AlAlaween and her team developed a new method to achieve right-first-time (RFT) production of healthcare products, making FDM a more viable option for product development. RFT production is a manufacturing approach that enables the successful development of products accurately on the initial attempt. The use of RFT production in the FDM process will enable manufacturing companies to accurately produce medical products thereby improving their profitable and competitiveness.

THE PROJECT

With support from the Transforming Systems through Partnership programme, this multidisciplinary project involved different disciplines including medicine, dentistry and engineering and was led by Dr Wafa AlAlaween at the University of Jordan. The project was conducted in collaboration with Professor Mahdi Mahfouf of the University of Sheffield and Printie 3D, a Jordan-based 3D printing company. The main aim of the project was to produce, for the first time in Jordan, products, such as surgical tools and patient-specific implants, using functional engineering materials e.g. semi-crystalline amorphous thermoplastics such as Polyether ether ketone (PEEK). The team's collaborative research during the project included carefully designed experiments to develop prediction models of the FDM process that would accurately predict the characteristics of 3D printed parts.

In doing so, the project team encountered a challenge in developing models that could accurately predict the product's mechanical properties. However, this challenge was resolved with the development of a more intensive model with accurate predictive performance that could produce the implants accurately.



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Lead partner: Dr Wafa AlAlaween, University of Jordan

IMPACT

Thanks to the project and the newly developed RFT method, the manufacturing process is now more accurate and more cost-effective. The **medical implants have been successfully implanted in patients** suffering from hemifacial microsomia and skull lacerations. These implants were **designed and 3D printed at 10% of the cost of implants produced by manufacturers based in Europe**. The reduced cost of these medical implants counts towards **a significant reduction in overall treatment costs for patients, improving the well-being of Jordanians and refugees who live in Jordan**.

"When you can see that you helped a 21-year-old patient, it's something really changing... My knowledge, my experience, whatever I learned during my life, [is used] to help these patients. It's really something different. I've never done something like this before"

Dr Wafa AlAlaween, Lead Partner

This project has **enhanced Jordan's additive manufacturing capabilities**. The successful **production of engineering-grade 3D printed products opens the door for commercialisation opportunities, especially in Jordan's healthcare sector**. The project was highly innovative as the improved FDM is a process that is rarely used in Jordan's healthcare sector. The project team has designed an RFT framework that can be used to identify the set of FDM parameters required to print 3D parts. This framework is based on the integration of fuzzy logic and multi-objective swarm optimisation and ensures that 3D printed parts are produced accurately. The use of the RFT framework can reduce the number of defects in FDM printed medical products and enable the addictive manufacturing industry to develop medical devices and implants cost-effectively.

"We've been able to carry out the project successfully with such a multidisciplinary team and with funding from the Royal Academy for which we are thankful of course, because they allowed the team to come together from both sides of the world and assemble a synergetic team."

Professor Mahdi Mahfouf

The project has led to **two academic papers** that the team have presented in different conferences.

THE FUTURE

The project team are continuing their collaboration and are now working on scaling up the results by starting a company to produce medical implants for the Jordan and Middle East market. Situating the company in Jordan will enable the project team to take advantage of Jordan's industrial zone which offers tax-free export to 21 Arab countries and the US. In future, the project team plans to expand the project by producing prosthetics that will be covered by skin cells to look like an actual human organ in terms of functionality and appearance.

SOURCES

This impact case study was prepared using information from interviews with the project team, documents supplied by the Academy including reports, and additional online resources.

- Application for Transforming Systems through Partnership Programme 'Right-First-Time Fused Deposition for Healthcare Manufacturing'
- The fused deposition for healthcare. Quarter 4 final report (February, 2023)
- Interview with Dr Wafa Alalaween, Dr Belal Gharaibeh and Professor Mahdi Mahfouf

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