IET National Travel Award 2022 Report

BMVA 3 Day Symposium: 4th-6th April 2022

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In early April 2022 I was awarded the IET National Travel Award to attend the "Special Event: BMVA 3 Day Symposium" in Manchester. This event was run by *The British Machine Vision Association and Society for Pattern Recognition* to bring together all machine vision researchers based in the UK through a comprehensive programme of keynotes, "missed" orals from recent online conferences, and extended poster sessions. Due to the global pandemic, during the first 2 years of my PhD at the University of Cambridge, I have been unable to visit any in person events or conferences. Therefore this symposium was a fantastic opportunity to present my work in person and learn about the latest research being undertaken in the UK. Most importantly, this event provided an opportunity to meet the community and establish relationships for future collaborations – whilst also having a good time with other machine learning researchers.

Having taken a somewhat rogue and red-eyed cross-country train route from Cambridge to the great city of Manchester, I arrived at the symposium, poster in hand, ready to talk shop. Over the course of the 3 days, there were 25 orals and over 65 posters presented with around 130 attendees. The predominant focus of the work was on the latest computer vision techniques, methods, and applications, with the majority of these works utilising deep learning approaches to achieve their results. There were many interesting research topics discussed, from the segmentation of tissue types in medical images, to trajectory attention in the latest video transformers, and even the use of AI in natural history production. Many of the approaches described provided inspiration for future work in my field: the application of machine learning in Additive Manufacturing (AM), also known as 3D printing.

At the symposium I was specifically presenting a poster of my work on *Vision based error correction in 3D printing*. 3D printers are awesome and offer vast opportunities across many industries, such as aerospace, medical devices, and robotics, as they can fabricate almost any geometry out of a wide range of materials. However, many applications remain at the research stage as printers are vulnerable to many manufacturing errors. These errors waste a significant amount of material, energy, and time. A particularly common error is warp deformation, where residual thermal stresses build in the part during its manufacture, causing it to deform from the desired shape. These errors are challenging to prevent or correct as they build over time and thus are only visible long after the actions that caused them. As a result, existing work has attempted warp detection but not correction or prevention. Our poster (see below) explained the hybrid approach we developed to solve this problem by combining deep learning, computer vision, and expert heuristics to correct or prevent warp. In the work we utilised low-cost off-the-shelf webcams to monitor the printing process and capture images in real time. Instances of warp deformation were labelled in these images and used to train deep convolutional neural networks. These networks enabled the accurate recognition and localisation of warp in future unseen prints. Five metrics were computed from detection candidates to predict the severity and growth of warp deformation during a print. The computed level of warp severity was subsequently used to automatically update numerous printing parameters. This enabled the first demonstration of automated warp detection and correction both during printing and for future prints. The research

work was of considerable interest to the wider computer vision community as a novel application of current techniques, particularly the use of humans in-the-loop through the combination of deep learning and expert heuristics. Many of the researchers at the symposium were not aware of the new and exciting field of applying machine learning to AM. I hope that after presenting this work I have inspired or at least tickled the curiosity of many to explore the topic further and increase the UK's research output in this area.

An additional benefit to the symposium were the fantastic networking opportunities in both an academic and business capacity. Currently I am in the process of spinning out my research as a start-up, Matta, and the event allowed me to meet world-class engineers in the machine learning field who could possibly join the team as we grow. Excitingly, I met people who were interested both in the possibility of working on a part time basis or joining after finishing their PhDs. Furthermore, this event has resulted in me being connected to people at the largest computer vision and machine learning labs across the UK, dramatically increasing the size of my existing network.

So, after a busy 3 days of learning, meeting people, and consuming fantastic food and drink provided by the Kimpton Clocktower Hotel venue, it was time to say farewell to Manchester and head back to the land of bikes and punts (there really is only one – sorry Oxford). I must thank the IET for enabling me to attend the BMVA 3 Day Symposium by fully funding the trip with their incredible National Travel Award. Without the IET's support, it would have been challenging to attend the event and our presented work would have received far less publicity.

Vision based error correction in 3D printing

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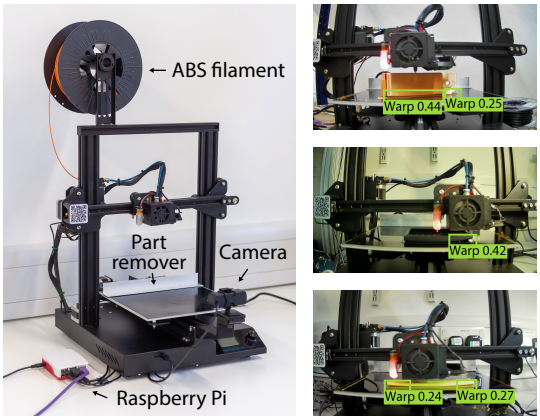
3D printing offers vast opportunities; however, many applications remain at the research-stage because printers are vulnerable to errors

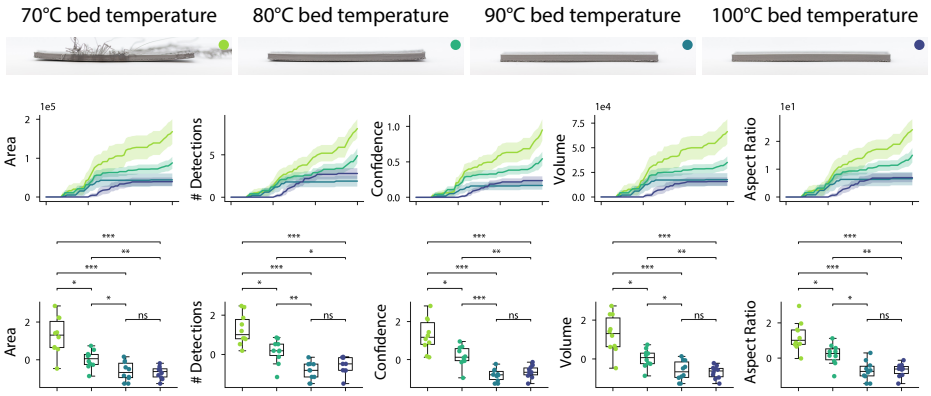
Material is deposited | Cools and contracts | Thermal stresses develop | Shrinkage causes corners to lift | Completed part is warped

Warp deformation is a common error that is challenging to prevent and correct as it builds over time

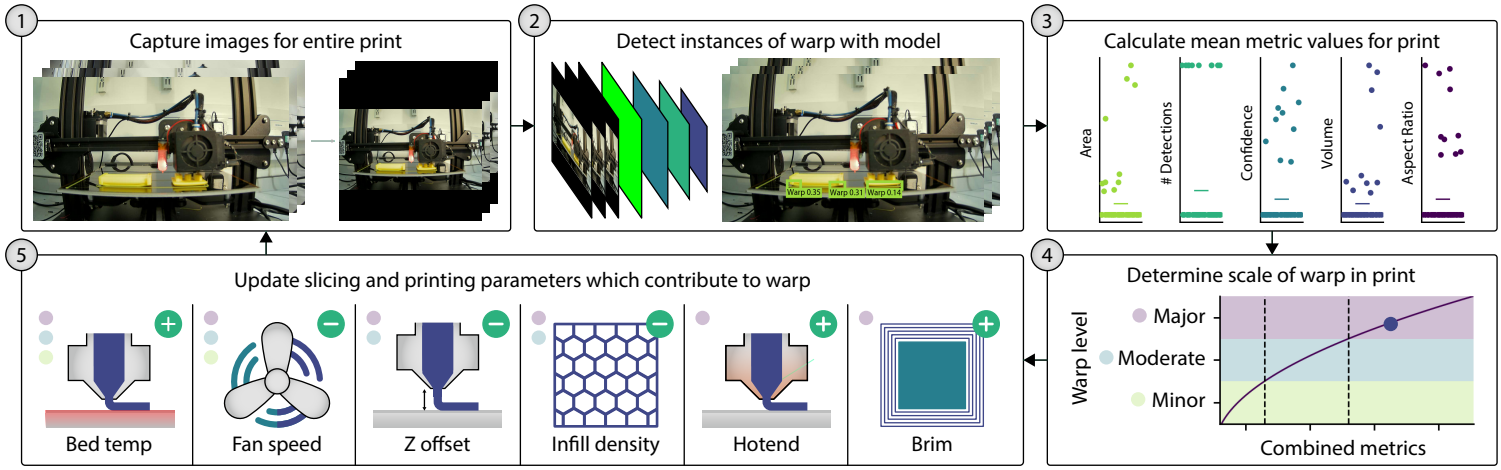
Printer-mounted cameras enable generation of training data



Metrics extracted from detection candidates allow the accurate estimation of deformation severity and growth



Warp severity predictions lead to autonomous correction and prevention of deformation



Reduction during printing

Original | Corrected

Correction between prints

Original | Corrected

Conclusion

Combined deep learning, computer vision, and expert heuristics to correct and prevent deformation

Demonstrated correction during printing and for future prints on a range of unseen geometries

Developed methodology could be applied to different printers, additive manufacturing technologies, and materials

Acknowledgements

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