Design and development of a low-cost AM system to help increase accessibility for people with sight loss

Nathan Lister[1], Kamila Jablonska[1], Tom Abram[1], Chris Lambert[1], Ivan Frontani[2] and Carolyn Dalton[2]

[1] School of Engineering, Gillow Avenue, Lancaster University, Lancaster, UK

[2] Lancaster City Museums, Market Square, Lancaster, UK

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The problem

Museums offer cultural experiences that help to bring history to life for visitors and local communities alike. Much can be learned by insights and reflections on historical events often symbolised by artefacts that depict them. For those with sight, these experiences can be educational as well as inspirational, as people are educated by history. However, for people who are visually impaired, seeking this fulfilment becomes a considerably greater challenge than those with sight. According to the World Health Organisation, globally, at least 2.2 billion people have a near or distance visual impairment (WHO, 2023).

Research aims

We wanted to help those with visual impairment to achieve higher levels of engagement with historic artefacts by using engineering design and development, including the use of additive manufacturing (AM). We had the following specific research questions:

- What are the most efficient ways in which AM can contribute to the problem statement?
- How can engineering design generate a product that helps to address the problem statement?
- In what ways can such a solution address the problem whilst placing a high priority on cost? (so that wider adoption is better achieved).

A high emphasis on these research questions was the notion of co-creation with end users, which remained a cross-cutting theme throughout the study.

Project team

The project team comprised six individuals, made up of researchers, technical and professional staff from the School of Engineering at Lancaster University. The team included the Exhibitions Officer and Museum Development Manager for Lancaster City Museums Service. The project would not have happened without the support and collaboration with Galloways, whose staff, volunteers and service users had a pivotal role to play. The diverse expertise of the project team contributed considerably to the product development cycle.

Users as co-designers

An important aspect to the design of the solution was that it had to be fit for purpose: to meet the requirements of people wishing to engage with historical artefacts that suffer with sight loss. Therefore, over the course of six months, the project team conducted four focus groups with service users of Galloways Society for the Blind, a local charity supporting people with sight loss. The focus groups contained were made up with participants with different degrees of sight loss, included completely blind. This helped the research team to incorporate features and make design decisions, directly informed by those with sight loss.

For example, we never considered at the outset how important audio output is for people with sight loss, however, this was a clear feature that all participants were in favour of. Embossed as opposed to debossed lithophanes were also universally favoured. And in terms of geometry, larger parts were consistently considered favourable over smaller parts.

Low-cost AM solution

In order for the solution to be as attractive as possible to museums, it had to be delivered with a low-cost budget. This is because museums lack resources outside of dedicated projects to fund such changes to their exhibitions and collections. It also had to be easily operated by non-expert users. At the time of procuring, we opted for an Ultimaker 3 as achieving a balance between cost and user friendliness. Recent reductions in cost of competitor FDM machines means alternatives may be more appropriate given the resource constraints in which museums operate.

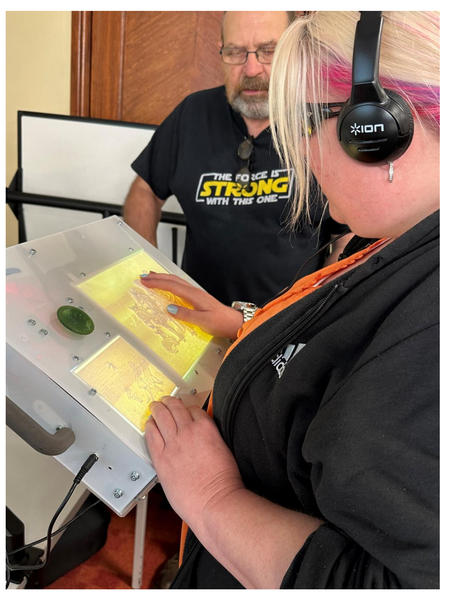
Polylactic acid (PLA) was selected as the most appropriate material, based on it being a biomaterial, low cost and easy to work with.

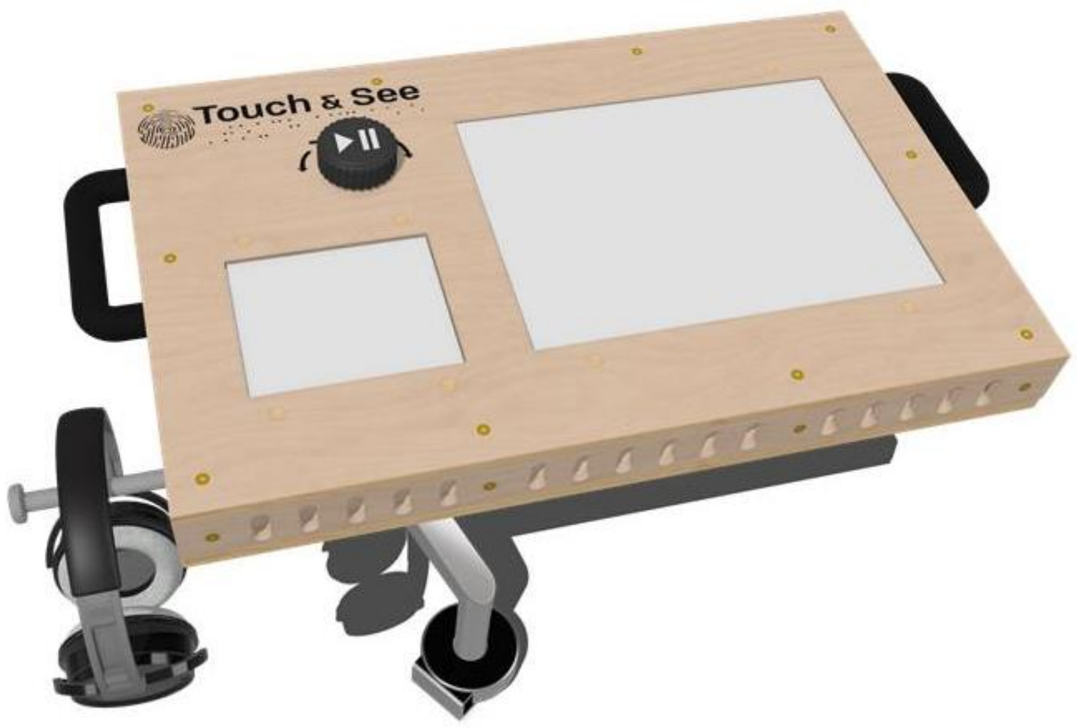
Electronics development

Version three of the case brings about the major change in the electronics. Aiming for improved efficiency, space savings and easy of assembly, the circuitry is reworked onto a printed circuit board (PCB). This allows for far more space in the housing and keeps everything compact with only one component to install. Additional functionality is also added such as:

- A rotary encoder for volume control and pushbutton functionality
- Built-in relay to reduce dependency on modules.
- Mounted Arduino Nano to reduce space.
- Power indicator LED
- Integrated power converter for 12V to 5V conversion
- Mounted headphone jack
- Jumper point and additional IO to allow for future amplifier implementation.
- Additional IO for future addressable LED support
- Mounted MP3 player

All individuals photographed provided consent for images to be used.





Final solution

The final product is not just informed by end users, but is co-designed by them, as active participants in the design journey. Feedback from every focus group was used to modify and iterate the subsequent version. This represents three versions of the haptic stand product

Utilising a PCB reduces noise and parasitics in the wiring, improving power consumption and audio quality. The use of AM in this research allows the resulting product to be low-cost, accessible to both users and non-technical staff and efficient. One such advantage of this is the speed in which lithophanes are generated, which if being produced manually by hand would take far longer, increasing development time and cost. This rapid manufacture allows for developments to be implemented in the lithophanes geometry as they are suggested, allowing quick and efficient testing.

The potential impact of this system is substantial, offering museums and other cultural institutions an affordable solution to increase accessibility by allowing visually impaired visitors to experience historical artwork in a more inclusive and engaging manner, with the history of the art being conveyed through detailed audio description. It is hoped that the findings from this will allow museums to better adapt artwork for visually impaired visitors in an enriching and welcoming experience.

Acknowledgements

We kindly acknowledge the input of two separate groups of undergraduate students who contributed to the development of the system. First was on assessing the feasibility of AM in being able to provide a solution and the second group on initial concept electronic and mechanical design generation for the haptic stand. The Touch & See project was funded by Lancaster University's Engineering and Physical Sciences Research Council (EPSRC) Impact Acceleration Account.

References

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Touch & See

Lancaster University

LANCASTER CITY COUNCIL
Promoting City, Coast & Countryside

Galloways
Support through sight loss