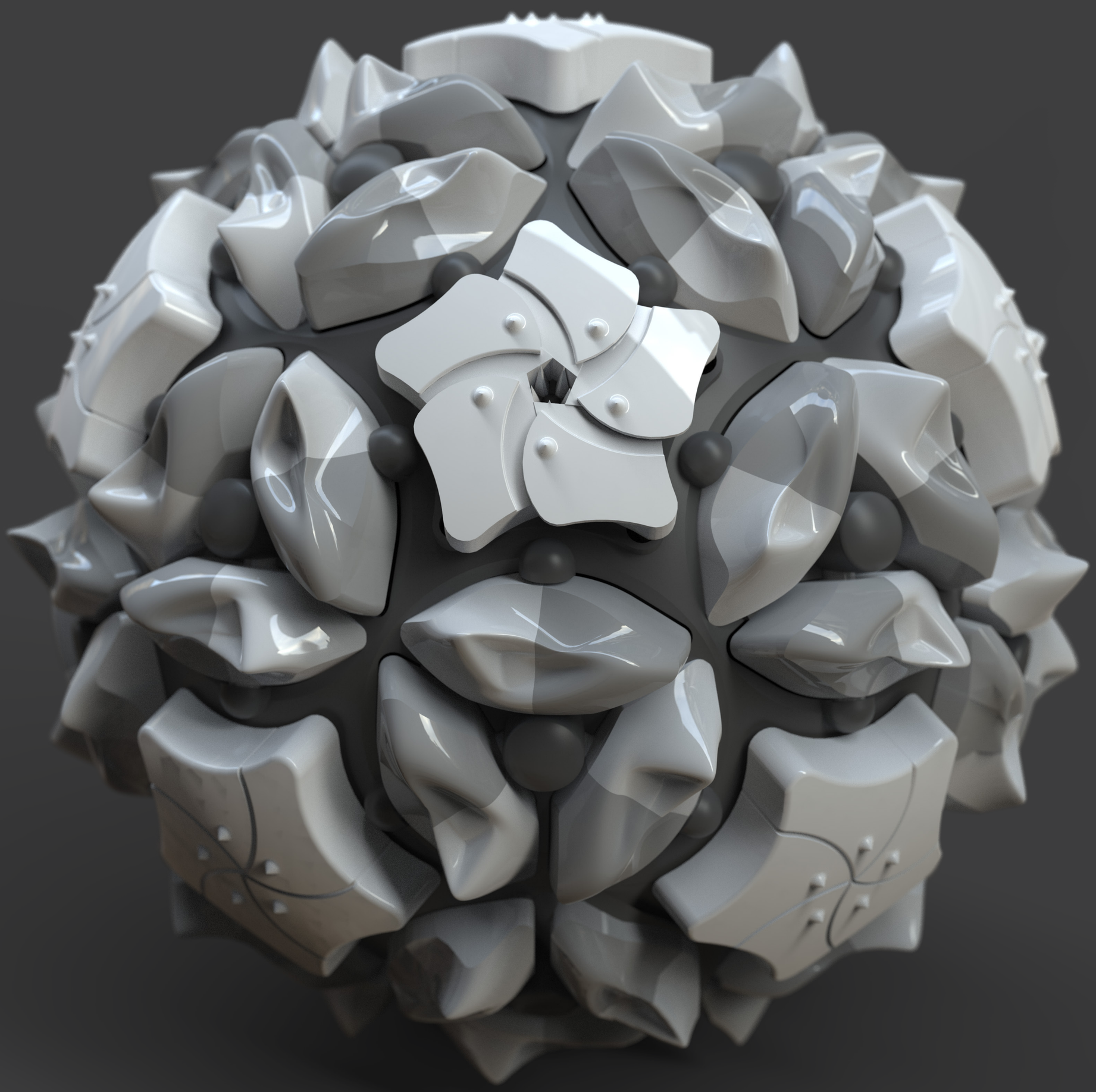
VIRUS MECHANICS PROJECT

UNIVERSITY OF LEEDS



BACKGROUND

This project involved collaboration between the Schools of Mechanical Engineering, Design and Biological Sciences. Using Poliomyelitis (Polio) as a model system, the project aimed to generate educational tools for science communication, student education and public engagement activites. The primary objective was to develop a 3D prototype model to show the anatomy and behaviour of virus structure, in order to communicate the mechanics of viral infection.

Most existing poliovirus representations are limited to topological models showing the capsid in a stable state. True understanding of viral infection mechanisms requires visualisation of the relation between the capsid components and their transformation into an active state.

The poliovirus capsid is a dynamic structure composed of 60 copies of four repeating structural proteins —VP1-4 —arranged with icosahedral symmetry. Receptors on VP1 proteins make contact with living cells, triggering structural rearrangement leading to cell membrane puncture and insertion of genetic material into the host cell.

PROCESS

Using a 'research through design' approach, virus structure and infection mechanisms were explored. Low fidelity prototypes of design mechanisms were created and evaluated against the set of design requirements.

An initial prototype was created to ensure that the design fulfilled the criteria and to show that the mechanical systems translated the movements correctly. A focus group with potential users provided valuable feedback regarding user interactions, ease of assembly and the structural robustness.

The multidiciplinary collaboration enabled the creation of a simplified, yet accurate representation of the poliovirus capsid, which showed the regions that are crucial to understanding the mechanisms behind viral infection.

The use of an LED to visualise the transmission of the genome into its active state, along with a carefully chosen colour scheme, allows easy visualisation of the capsid symmetry and avoids the misinterpretation of structural elements.

OUTCOME

This project has contributed to the development of STE(A)M initiatives – integrating the arts within STEM – between the Faculties of Engineering, Arts and Biological Sciences.

The poliovirus model was manufactured using 3D printed PLA plastic which was post-processed and painted in distinct colours. Addition of a soldered circuit allows the structure to emit a bright light while in an active state.

The finished model will form an educational tool to help learners understand the mechanics of how the capsid transforms, the role of antibodies during infection and the potential for antiviral drugs to affect different regions of the virus.

The final prototype will be evaluated during public engagement activities in order to inform the development of further educational materials. A paper will be presented at Bridges 2020 (Finland) and the prototype model displayed in the mathematical art exhibition.

INACTIVE STATE

ACTIVE STATE

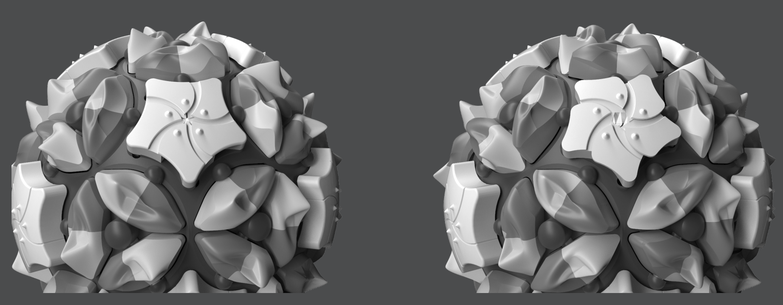


Figure 1 : Poliovirus model showing the structure in inactive and active states

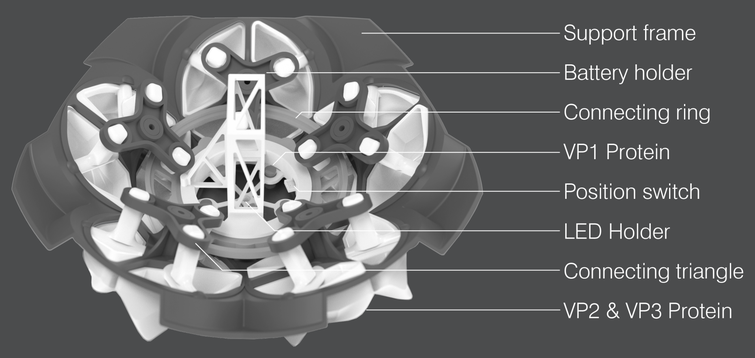


Figure 2 : Schematics of the mechanical system within the capsid

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