Optical system for spheroid analysis

Student

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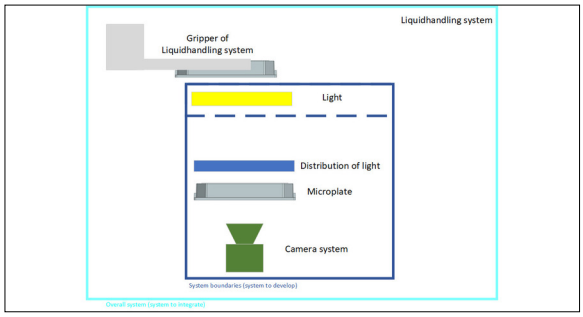
Introduction: Three-dimensional (3D) cell cultures, especially spheroids, have become increasingly important in research and drug development in recent years. These cultures are often processed using automated liquid handling systems. Various methods exist for assessing the quality of such cultures, but a fast, directly integrable on-deck solution for checking presence and performing simple analysis during the pipetting process is still missing.
The aim of this semester project was to develop a prototype that can be integrated into a liquid handling system. The system should enable the rapid detection of entire microplates and reliably detect the presence of spheroids directly on the deck of the liquid handling system.

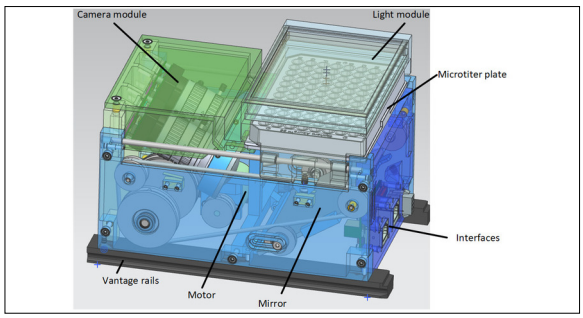
Approach: The work was carried out as part of an industrial project in cooperation with the company InSphero. In the first phase, the system requirements were defined, and a market analysis of existing solutions was carried out. Various concepts were then developed using a morphological box and supplemented by optical feasibility studies.
An important aspect was the reduction of the system footprint while at the same time ensuring sufficient image quality. For this purpose, a concept with condenser lenses was selected, which enables a reduction in the working distance. This was followed by the mechanical design, the selection of components and the development of the software for image acquisition and processing. The image processing was implemented in Python using OpenCV. Two classic image processing algorithms were implemented: one to detect centrally located spheroids and a second to differentiate between spheroids and shadow artifacts.

Result: The prototype developed is functional and enables the automatic scanning of inserted microplates. The system captures the image data, controls the lighting and detect spheroids. While detection in central wells works reliably, contrast and distortion problems occur at the edges of the plates. These result from the illumination angle being too flat at a short working distance, which makes structures in the background visible and makes the detection more difficult.
Two approaches are recommended to improve the optical quality: Either increasing the working distance to eliminate condenser lenses and reduce the shadowing artefacts or developing a precisely designed optical system with customized components, adapted to the geometry of the microplates.

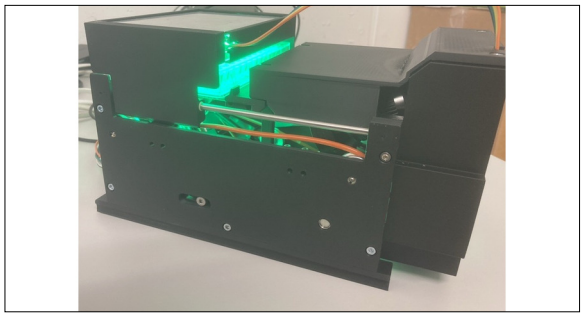
System overview
Own presentment



CAD design
Own presentment



Prototype
Own presentment



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Subject Area
Medical Engineering, Mechatronics and Automation