Insights into Tumors: Morphological Analysis of Spheroidal Tissue Models

Dalia Mahdy [1] and Jan Hansmann [2 3]

[1] Graduate School of Life Sciences, Julius-Maximilians-Universität Würzburg, 97074 Würzburg, Germany.
[2] Translationszentrum für Regenerative Therapien TLZ-RT, Fraunhofer Institute for Silicate Research ISC, 97070Würzburg, Germany.
[3] Institute of Medical Engineering Schweinfurt, Technical University of Applied Sciences Würzburg-Schweinfurt, 97421 Germany.

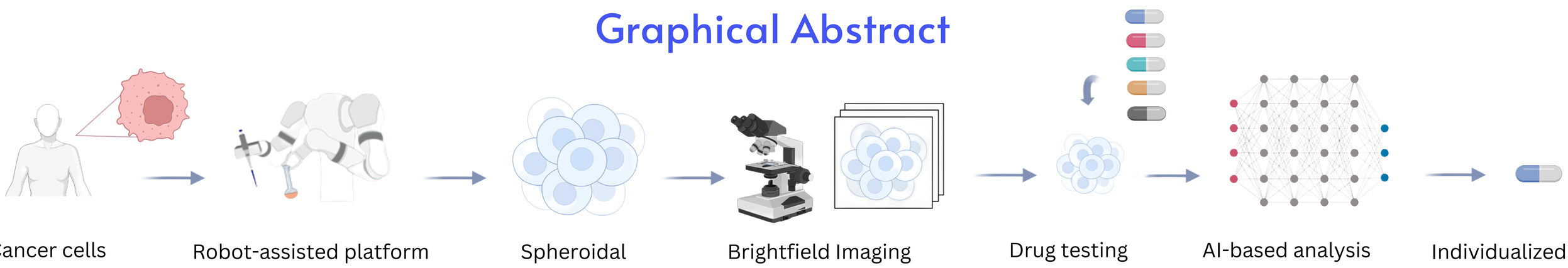
Motivation

Pancreatic ductal adenocarcinoma (PDAC) has a poor prognosis, with a 5-year survival rate of 7–11%. Traditional 2D models often fail to replicate tumor complexity, leading to inaccurate drug efficacy assessments. While 3D spheroids provide a better alternative, manual production and analysis are time-intensive and inconsistent. This study addresses these challenges by integrating robotics and AI for automated, scalable, and precise spheroid generation and analysis.

Aim

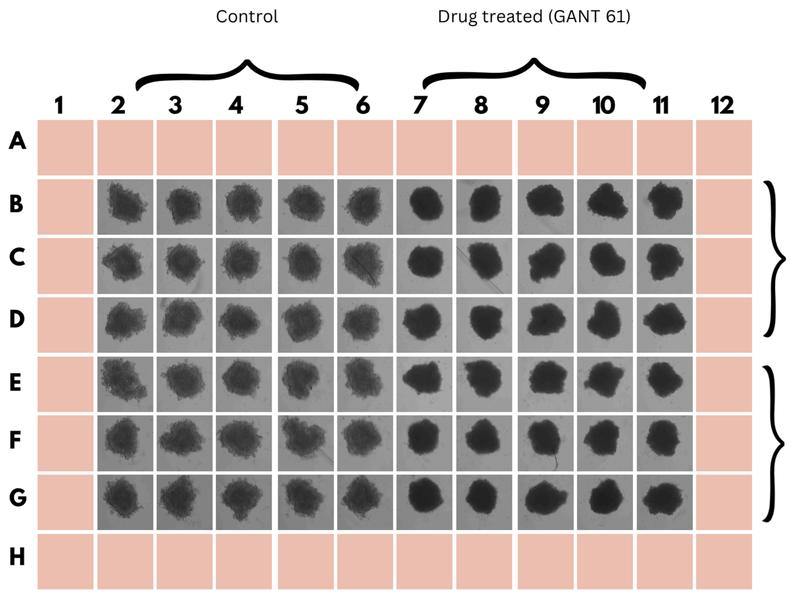
This study aims to develop a framework that combines robot-assisted spheroid production with AI-based monitoring and analysis. The objective is to enable high-throughput and reproducible characterization of PDAC spheroids, facilitating the evaluation of therapeutic responses. By integrating segmentation, validation, and quantitative morphological assessments, the framework supports the standardization of experimental workflows and enhances the reliability of drug testing.

Graphical Abstract



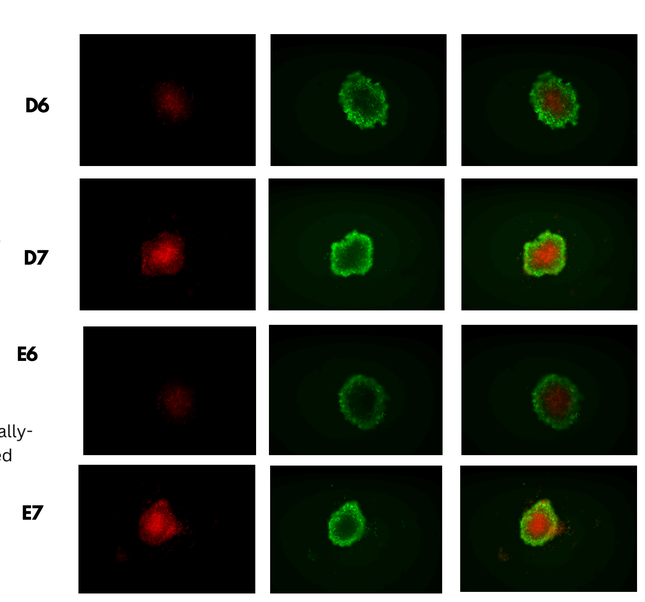
Results

Brightfield Imaging

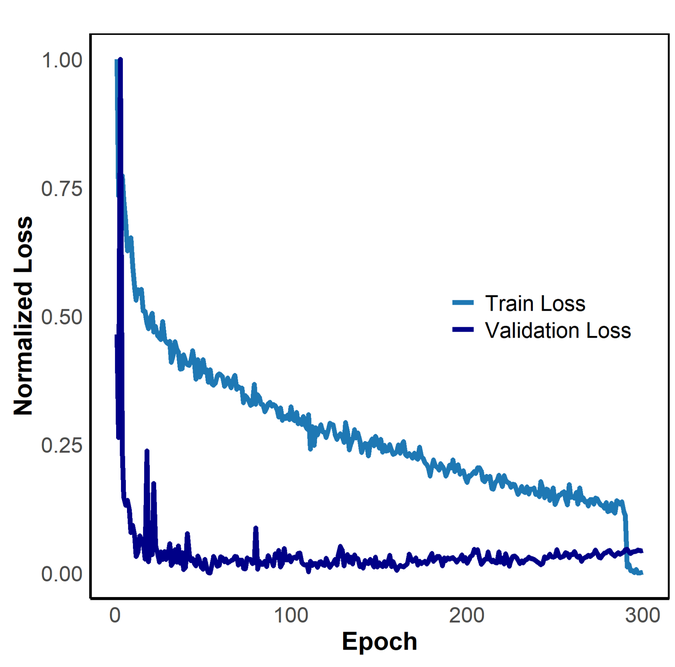


Spheroidal Tissue models 96 welll-plate

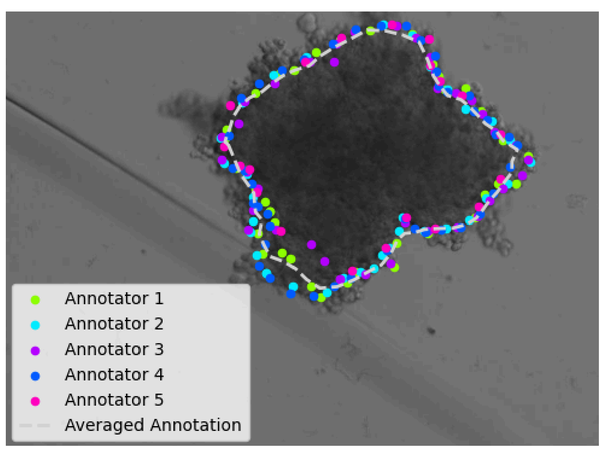
Fluorescence Imaging



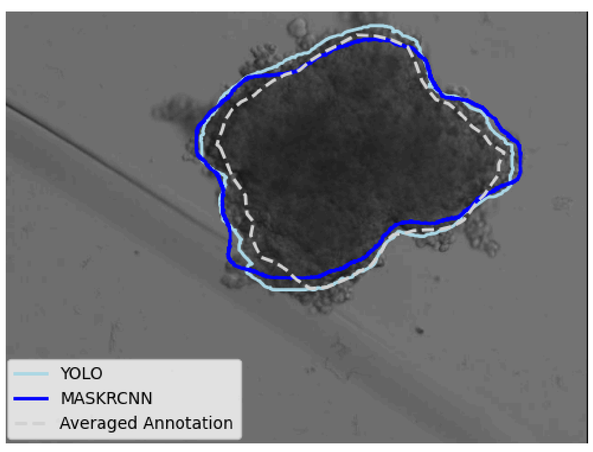
Training



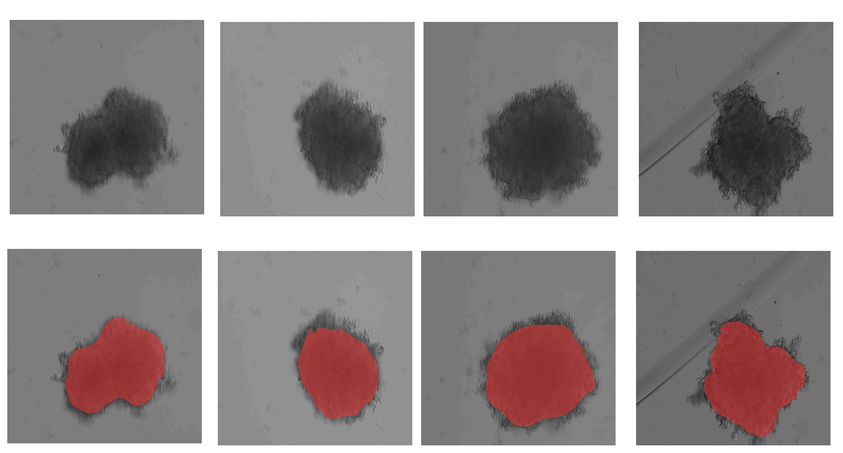
Annotation



Manual vs. Automated Identification



Acquisition and segmentation output from test dataset



Conclusions

- Integrated an AI-based pipeline for spheroid validation and segmentation, achieving 99.5% precision and recall in boundary identification.
- Reduced manual variability by aligning YOLOv8 segmentation results with expert annotations.
- Enabled consistent and detailed assessment of drug responses, supporting advancements in personalized cancer therapy.