HSLU Hochschule Luzern

Technik & Architektur

Konstruktion und Tragwerk (Zusatz 1)
Bachelor-Thesis Medizintechnik (Zusatz 2)

Bachelor-Thesis Medical Engineering | Life Science

openBudgetScope – A Low-Cost Microscope

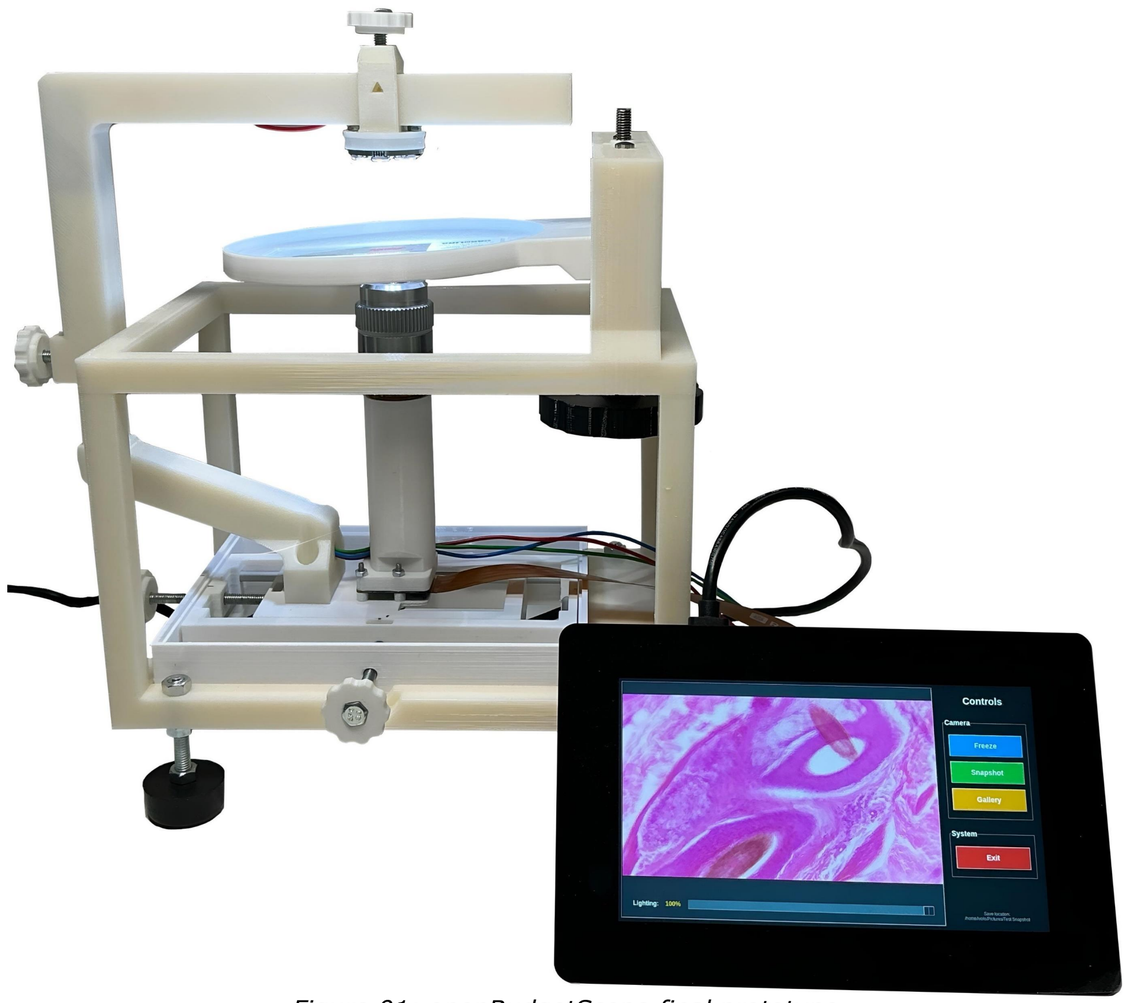

Figure 01: openBudgetScope final prototype

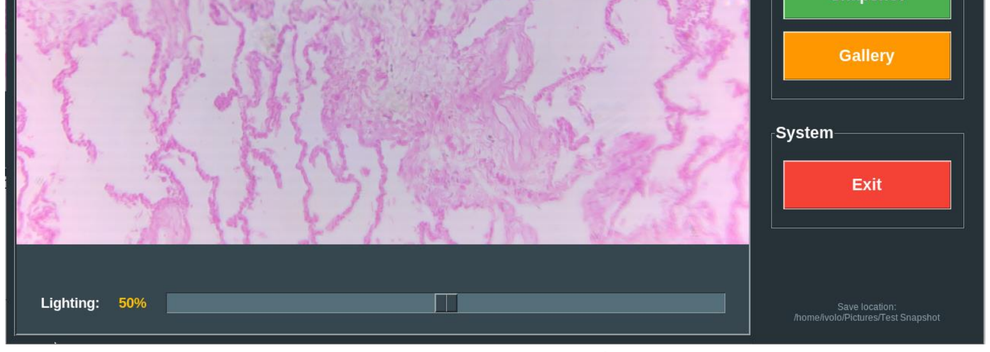

Figure 02: GUI-Overlay

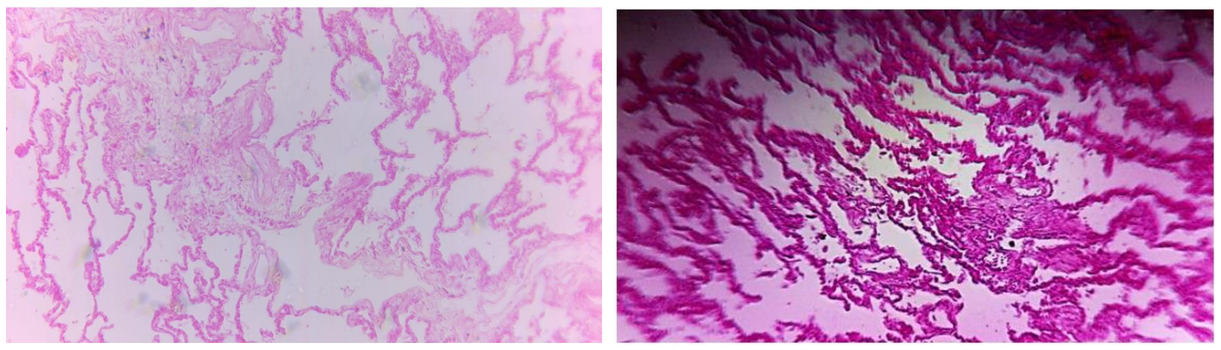

Figure 03: Direct image comparison of a human lung sample from openBudgetScope (left) to openµView (right)

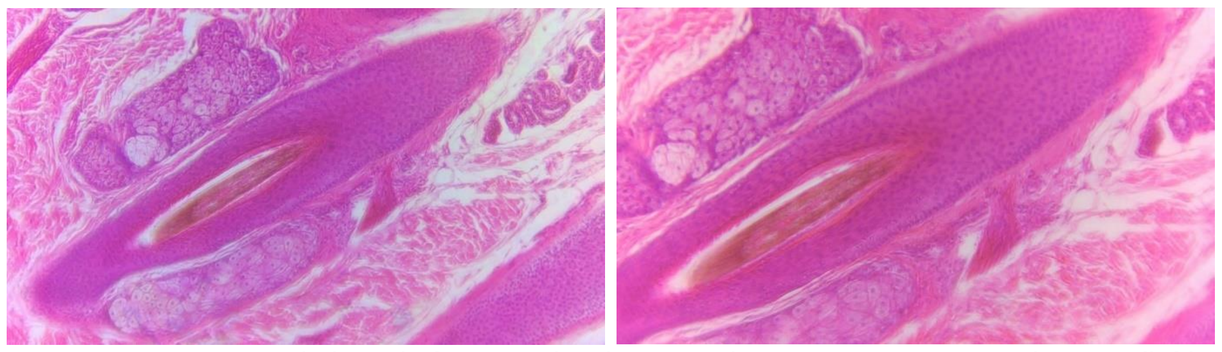

Figure 04: Human scalp hair shafts imaged with openBudgetScope using a 10× objective (left) and a 20× objective (right).

Nr.	Function	Criteria weight / Weighted Score	Normalised [1;100%]
F01	Enable manual zoom and focus	126.85	81.03%
F03	Capture high-resolution images of biological samples	107.38	68.60%
F05	Adjust illumination intensity	104.46	66.73%
F12	Maintain stable focus during imaging	111.85	71.45%
F14	Protect optics and electronics during transport	105.38	67.32%
F15	Allow 3D printing or laser-cut fabrication	122.46	78.23%
F21	Save digital images locally	116.38	74.35%
F23	Provide intuitive user interface (GUI/buttons)	114.08	72.87%
F25	Operate on USB-OTG or battery (no external power)	118.23	75.53%
F29	Prevent overheating during extended use	120.69	77.10%
F30	Support educational and citizen-science use	118.31	75.58%
F36	Use low-cost, off-the-shelf components	123.23	78.72%
F37	3D printing and laser cutting	115.77	73.96%

Figure 05: Extract from the trade-off table with high-priority functions

Nr.	Function	Criteria weight / Weighted Score	Normalised [1;100%]
F02	Enable automatic zoom and autofocus	101.38	64.77%
F06	Support multiple illumination modes (e.g., dark-field, Rhe	99.23	63.39%
F07	Capture large sample areas via image stitching	93.92	60.00%
F11	Support safe alternative staining methods	99.31	63.44%
F17	Reduce vibration for long exposures	100.00	63.88%
F18	Compact and storable design	94.38	60.29%

Figure 06: Excerpt from the trade-off table with optional functions

Problem Statement

Low-cost and open-source microscopes enable access to microscopy in education and frugal science, but their optical quality and usability are often limited by simplified optics, non-uniform illumination, and constrained mechanical stability.

The openµView microscope is one such low-cost open-source microscope. It was developed by the HSLU. It offers a strong foundation, but its single-lens design and compact mechanics limit the usable magnification, edge sharpness and overall image sharpness.

This thesis examines the requirements search, as well as the the challenge of improving the optical performance and practical usability while keeping the system affordable, reproducible and based on globally available off-the-shelf components.

Solution Concept

A structured, literature-driven requirements engineering process was used to identify and prioritise relevant microscope functions.

A weighted trade-off analysis defined which functions should guide the redesign. Based on these results, a proof-of-concept prototype was developed as a modular system combining updated electronics, a redesigned mechanical stage (X/Y/Z), and a simplified but complete GUI workflow. The optical concept was upgraded to an objective-plus-tube-lens architecture using a 50 mm achromatic tube lens, enabling compatibility with both finite and infinity-corrected objectives while keeping the optical layout compact.

Results

A trade-off evaluation was used to separate high-priority from optional functions, which guided the proof-of-concept prototype, a standalone system combining mechanics, electronics, and a custom GUI. The GUI provides a live camera preview, adjustable illumination brightness, and an optional freeze mode. Images can be captured via snapshot, stored automatically, and reviewed through an integrated gallery within the same application. To illustrate optical performance, the same sample was imaged with a 10x and a 20x objective for direct side-by-side comparison. In addition, benchmark images were captured and compared against the original openµView reference to visualise differences in overall image quality. To illustrate optical performance, the same sample was imaged with a 10x and a 20x objective.

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