THE μVID SYSTEM

A UNIVERSAL VISUALISATION, IMAGING, AND DETECTION SYSTEM VIA CO-ROTATING COMPUTATIONAL IMAGING AND ANALYSIS APPLIED TO AUTONOMOUS LAB-ON-A-DISC SYSTEMS

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1. Introduction

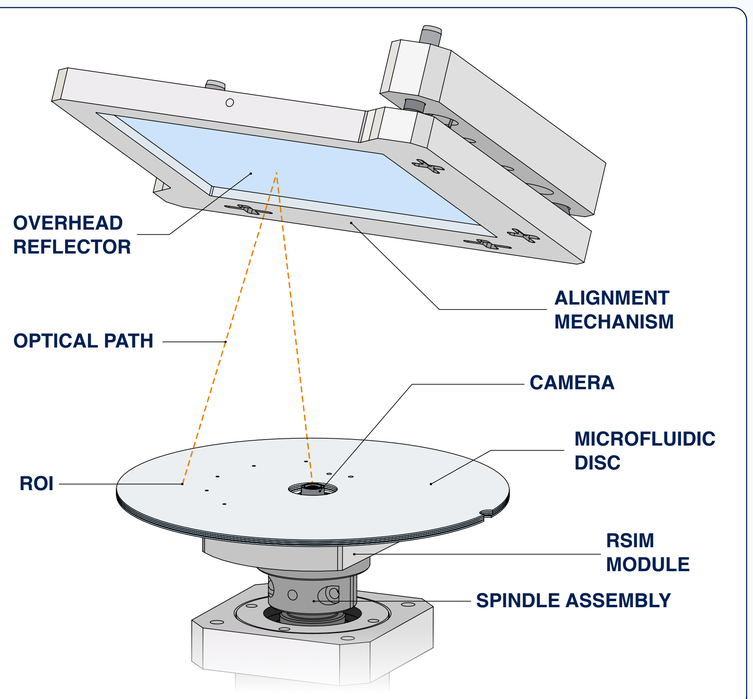
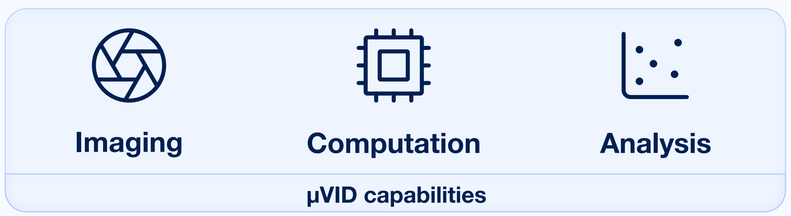


Fig 1. Schematic overview of the μVID architecture

- Existing methods of LoaD imaging during rotation limit real-time monitoring, kinetic measurements, and process quality control.
- **μVID images the disc using a co-rotating camera viewing the disc through a stationary overhead mirror, keeping microfluidic features spatially fixed in the image during rotation** (Fig. 1).

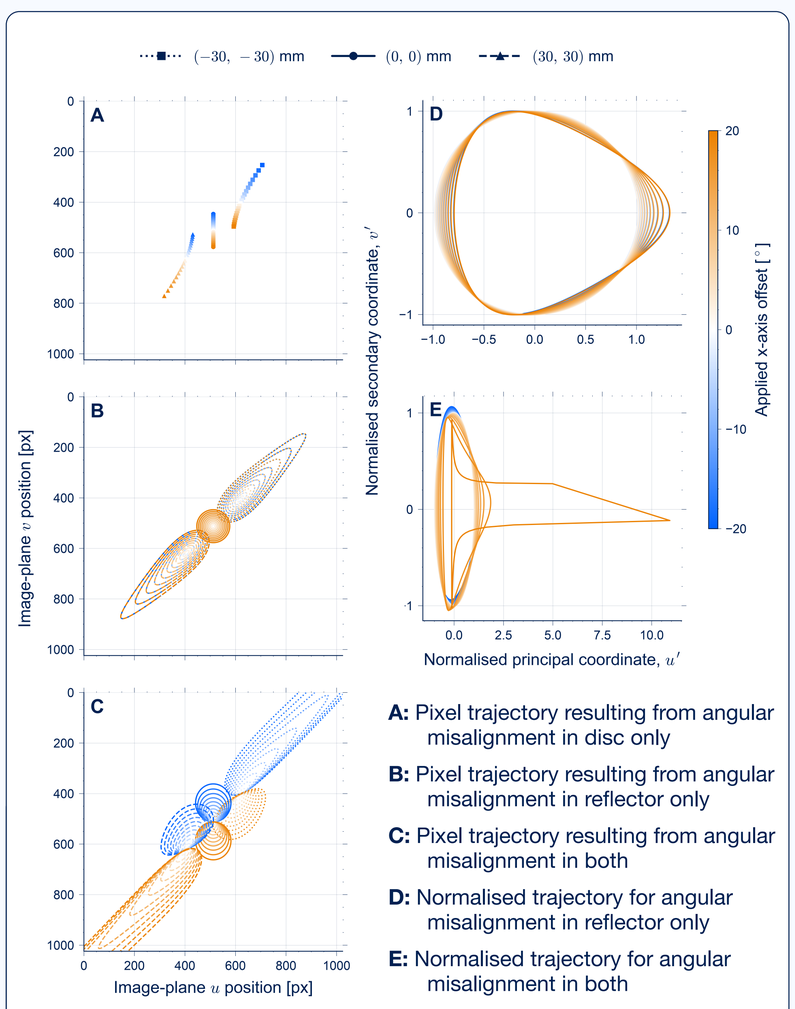


2. Methods

2.1 Geometric Optical Model

- Geometric forward model developed **to characterise the effects of reflector and disc misalignment on image stability** during rotation (Fig. 2).

$$\mathbf{X}_{MD} \rightarrow \mathbf{X}_{W}(\theta) \rightarrow \mathbf{X}_{virtual}(\theta) \rightarrow \mathbf{X}_{OS}(\theta) \rightarrow [u(\theta), v(\theta)]$$



A: Pixel trajectory resulting from angular misalignment in disc only

B: Pixel trajectory resulting from angular misalignment in reflector only

C: Pixel trajectory resulting from angular misalignment in both

D: Normalised trajectory for angular misalignment in reflector only

E: Normalised trajectory for angular misalignment in both

Fig 2. Simulated image distortion resulting from misalignment



Type of disturbance arising from type of misalignment

2.2 Disc Design

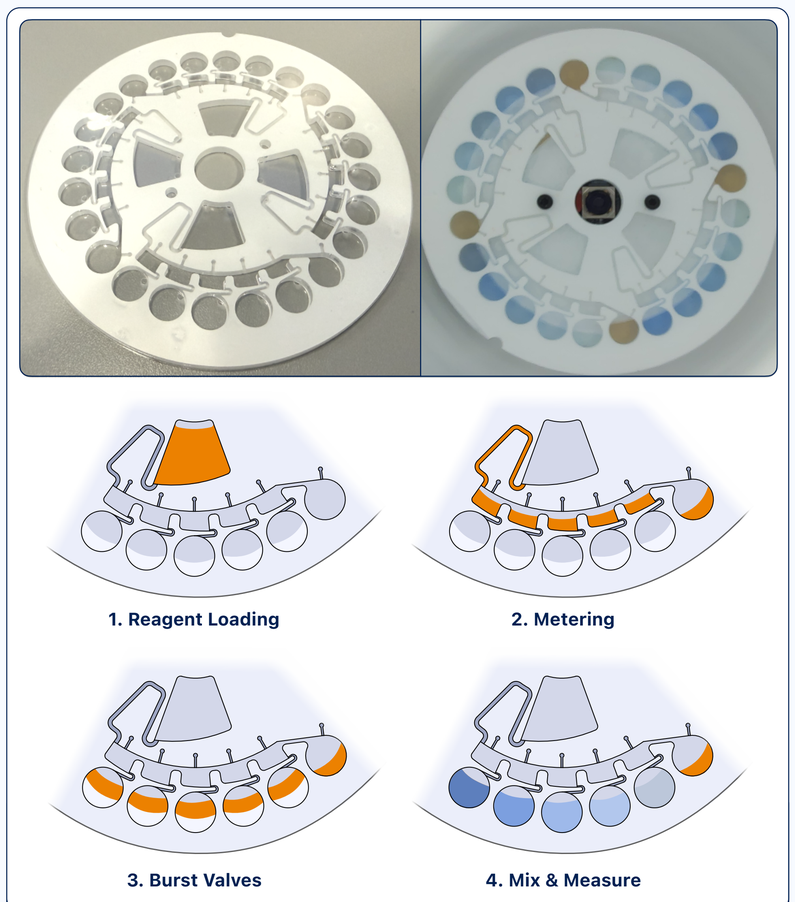


Fig 3. Lab-on-a-Disc and four-stage Bradford assay workflow

- Microfluidic disc fabricated from laser-cut PMMA layers bonded with PSA.



Functionality of colourimetric Bradford assay

2.3 Experimental Setup

- Experimental configuration is illustrated in Fig. 1, with the **overhead reflector aligned parallel** to the disc.
- **Image processing and quantitative analysis were performed onboard, with acquired images stored for subsequent review and validation.**

3. Results

3.1 Imaging Performance

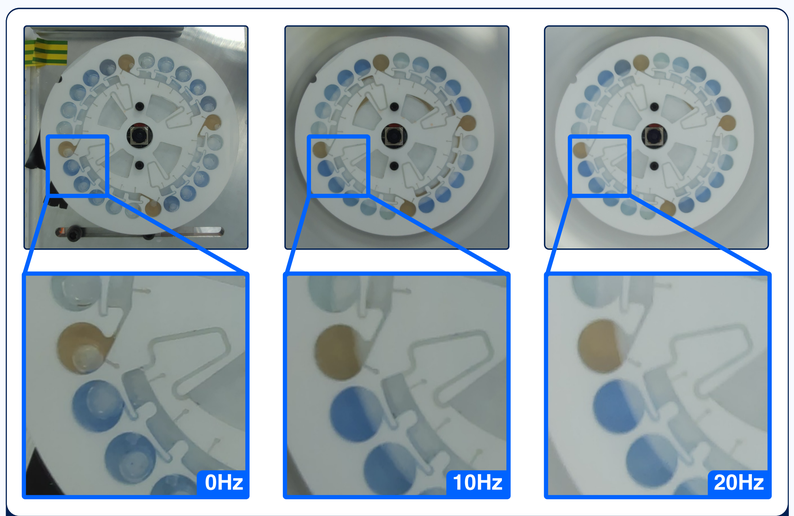


Fig 4. Imaging performance at different rotation frequencies

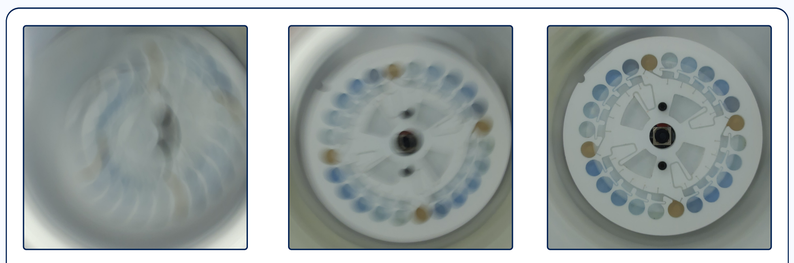


Fig 5. Imaging performance with different degrees of misalignment



Qualitative imaging performance summary

3.2 Biochemical Validation via Bradford Assay

- **Automated image processing** identified individual reaction chambers and **extracted regions of interest (ROIs) for quantitative analysis** (Fig. 6) rotating at 20Hz.
- Bradford assay measurements demonstrated a **linear response across BSA concentrations of 5–25 μg/mL (R^2 = 0.9740), with coefficients of variation (CV) ranging from 2.1–5.1% across replicate measurements.**
- **Results demonstrate μVID's potential for direct and automated quantitative biochemical analysis from images acquired on the rotating platform.**

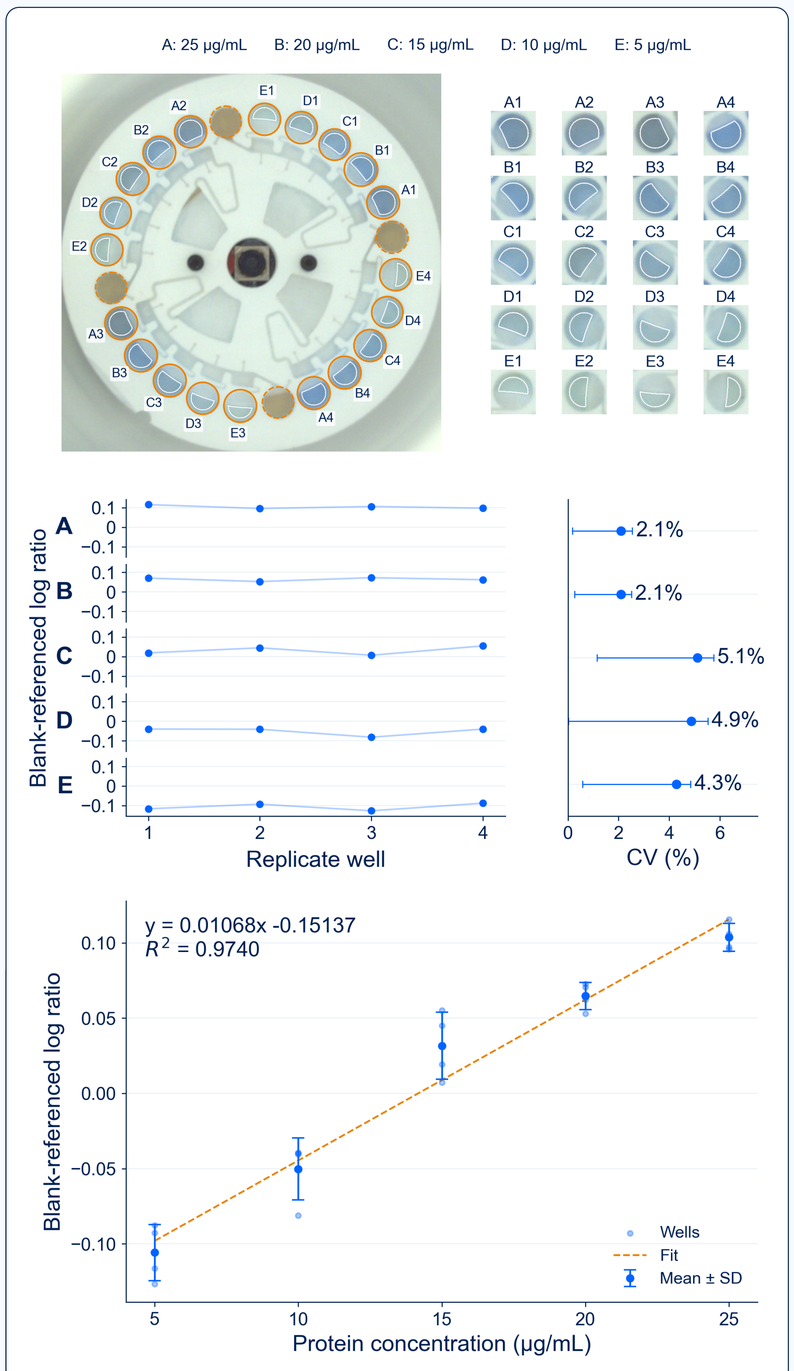


Fig 6. Automated reservoir detection and quantitative assay validation

4. Conclusions

Co-Rotating Imaging

Clear visualisation of microfluidic features during rotation.

Optical Modelling

Quantitative prediction of pixel trajectory arising from reflector and disc misalignment.

Biochemical Validation

Automated chamber detection and quantitative Bradford assay analysis (5–25 μg/mL; R^2 = 0.9740).

5. Future Work

- Enabling higher speeds using an improved spinstand.
- Resolving edge softening resulting from both vibration and slight planar misalignment.
- Improve disc design to enable uniform filling and mixing.
- Improve illumination uniformity.

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Scan for an interactive demonstration