MEng Project 2

AI-Assisted Masking and Quality Control for Particle Image Velocimetry

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Project objective and research question. This project will create an automated, auditable workflow for identifying solid boundaries, reflections, poorly seeded regions, and unreliable vectors in PIV images and velocity fields. The research question is whether modern segmentation and anomaly-detection tools can reduce manual masking effort without introducing bias into mean velocity, Reynolds stresses, vorticity, or pressure reconstruction.

Engineering-science foundation. The project draws on image formation, correlation-based velocity measurement, sampling and uncertainty, boundary-layer and separated-flow physics, statistical outlier detection, computer vision, and supervised or self-supervised learning. Engineering judgment is required to distinguish optical artifacts from real flow structures.

Methodology, data, and scope. A representative set of archived PIV images will be manually annotated to establish reference masks and quality labels. The student will benchmark classical intensity and morphology methods against one or more foundation-model or lightweight segmentation approaches. Image-level masks will be combined with vector-level indicators such as signal-to-noise ratio, normalized median residual, local divergence, and temporal consistency. Performance will be evaluated both as a computer-vision task and by its downstream effect on PIV statistics and derived pressure. The final implementation will expose confidence scores and retain manual override. Python, OpenCV, OpenPIV, and PyTorch will be used.

Success metrics and contingency. Intersection-over-union and precision/recall for masks; false rejection of valid vectors; changes in mean velocity, turbulence statistics, vorticity, and pressure; processing time; and reduction in manual review. If foundation-model fine-tuning is impractical, the fallback is a reproducible hybrid workflow using prompted segmentation, classical morphology, and physics-based vector checks.

Two-Term Work Plan and Deliverables

Term	Planned productive work	Deliverable due by the last day of lectures
1	Literature review and requirements (18 h); assemble and annotate dataset (35 h); reproduce classical masking and vector-validation baselines (32 h); test segmentation models (40 h); document evaluation protocol (15 h). Total: 140 h.	Interim report, curated benchmark dataset, baseline results, and documented prototype pipeline.
2	Integrate image- and vector-level quality checks (45 h); tune and validate on withheld cases (35 h); quantify downstream flow-field effects (30 h); develop user-facing workflow and documentation (20 h); final report and presentation (20 h). Total: 150 h.	Validated software pipeline, annotated test set, engineering report, and final presentation.

Expected outcome. A practical quality-control tool that accelerates PIV processing while making the consequences of AI-based masking measurable and reviewable.