A fully open-source system for prospective optical gating in 3D fluorescence light sheet cardiac imaging

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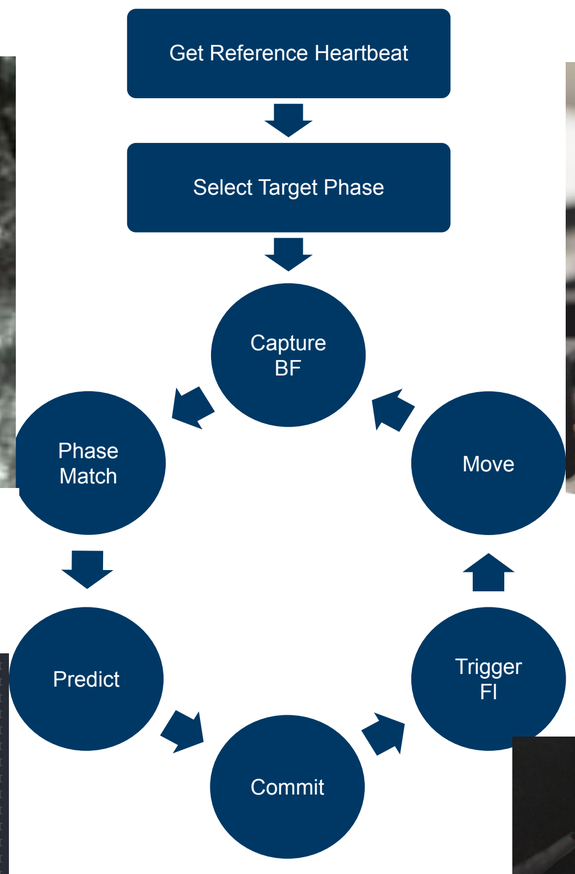
Cardiac diseases account for more deaths worldwide than any other cause. The zebrafish is a commonly used and powerful model organism for investigating cardiac conditions with a strong connection to human disease. This is important for furthering biomedical sciences such as developing new disease models or drugs to combat those diseases.

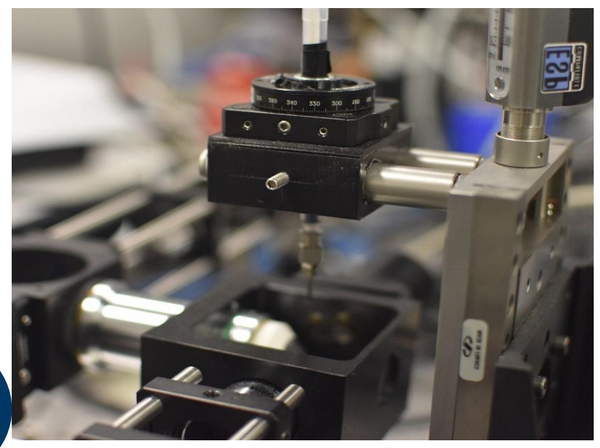
Prospective optical gating technologies allow 3D, time-lapse microscopy of the living, beating zebrafish heart without the use of pharmaceuticals or electrical/optical pacing [1]. Further, prospective optical gating reduces the data deluge and processing time compared to other gating-based techniques. However, currently these systems requires specialist, custom-made timing boxes and highly sophisticated system-specific software. In order to make these tools more widely available to research groups around the world we have ported these technologies onto the popular, single-board computer, the Raspberry Pi with Python code for prospective optical gating, microscope triggering and a simple GUI for user-friendliness.

Our fully open-source system is able to perform prospective optical gating with a quality near that achieved by custom and specialised hardware/software packages. We hope that by moving this project into the open-science sphere we can ensure that all groups with an interest are able to implement prospective optical gating in a cheap (<50 Euros) and simple way.

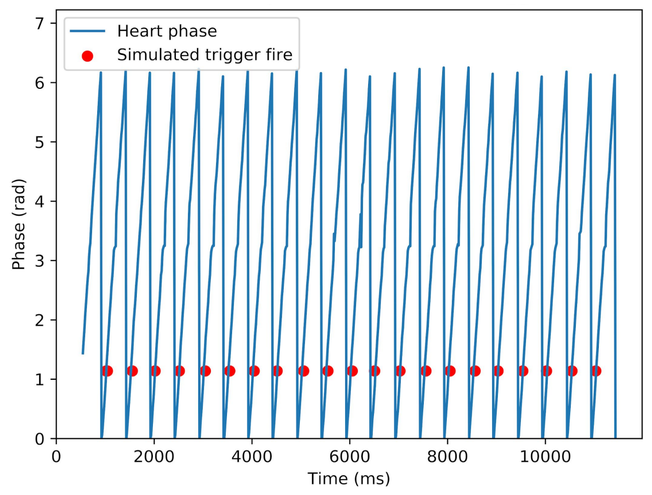
Open-Source Prospective Optical Gating Using a RaspberryPi, PiCam Noir and a custom Python module

Capture Brightfield PiCam Noir Image of Heart





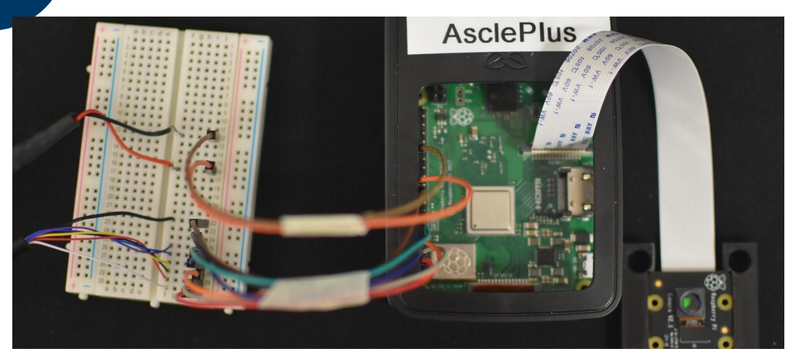
Move Stages over RS-232



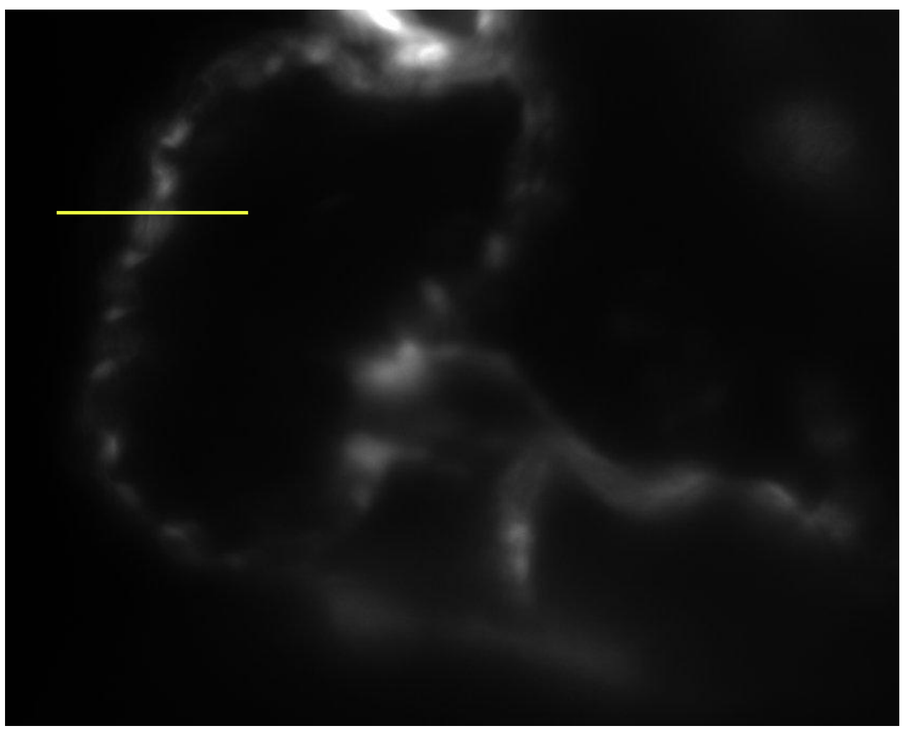
Gating Accuracy

The above plot shows (in blue) the heart phase obtained by our open-source prospective optical gating system. The points (in red) display the times at which the camera and laser are triggered for synchronised imaging.

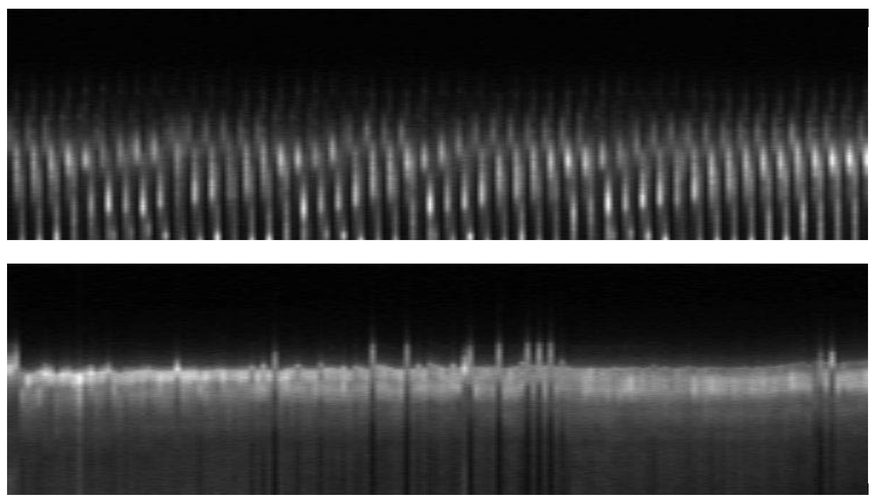
Open-Source Optical Gating Algorithm



Trigger lasers and cameras via TTL signal



Example fluorescence image captured using open-source prospective optical-gating system.



Kymographs of the cardiac wall (yellow line, left) show the period motion of the heart wall (top) can be computationally frozen using our open-source prospective optical gating system (bottom) with fairly consistent results.

This work is currently in preparation, but you can access the early development codes (no UI) at **github.com/Glasgow-ICG/open-optical-gating** or scan the QR code below.

1. Taylor, J.M., Nelson, C.J., Bruton, F.A. *et al.* Adaptive prospective optical gating enables day-long 3D time-lapse imaging of the beating embryonic zebrafish heart. *Nat Commun* 10, 5173 (2019) doi:10.1038/s41467-019-13112-6

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