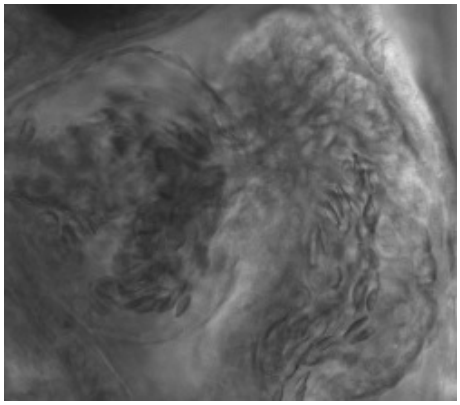
High precision analysis of heartbeat information



Our group has developed precision video analysis techniques that can be applied to heart motion in the zebrafish to achieve high-resolution image synchronization for 3D+time imaging, but we believe there is also a wealth of physiological information waiting to be mined from our video datasets. This project will develop automated methods to investigate heart rate variability on scales ranging from minutes down to fractions of a heartbeat, seeking to develop and apply signal processing techniques to obtain information about heart performance that will be of interest to biological researchers studying heart performance, drug interactions and cardiovascular diseases.

Theory

by J. TAYLOR

Much biomedical insight has been gained from studying animals as a model for human development and disease. The zebrafish has the particular advantage that it is transparent, meaning that its simple two-chamber heart can be imaged using conventional optical microscopy. This offers a window into early heart development under normal and diseased conditions. However, image acquisition is only the start of the process: the big challenge is in processing and interpreting the raw video data. Even basic automated image analysis is a potential non-contact method for studying heart rate variability between beats and also subtle variations in how each beat takes place – giving access to much more information than "a biologist with a stopwatch"! The majority of published biological research is restricted to very crude metrics, but it is known that more subtle effects are present that are generally ignored.

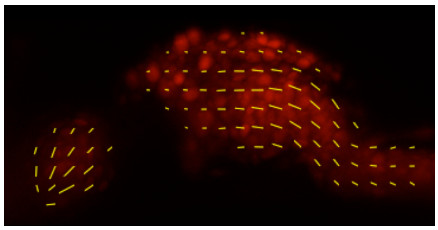
Furthermore, advanced image analysis (micro-particle image velocimetry) can offer insight into the blood flow within the heart, and its relationship to the structure of the heart. The question then arises: in the realistic case where the heartbeat is not perfectly periodic, how close is this relationship? Does each beat still pump in the same way, even if the intervals between beats might vary? At what point is the arrhythmic heart fundamentally different in function? All these questions can potentially be answered through automated video image analysis.

Applications

by J. TAYLOR

This project will analyze video microscopy data acquired from living zebrafish embryos, using generic image processing and signal analysis techniques that are equally applicable for astronomical observations. Previous research has established [1, 2] that it is possible to analyze brightfield video imagery of the heart in realtime in order to "lock in" to the heartbeat and trigger synchronized image acquisition.

The student will apply related image-similarity and phase assignment algorithms to characterise the changing behaviour of the heart. Information will be compared from both structural information and blood flow information (obtained from particle image velocimetry analysis of moving red blood cells) in order to explore the relationship between flow and function for the case of an arrhythmically-beating heart. No knowledge of biology is required for this project; training will be provided in the image and signal analysis techniques used, but prior familiarity with the python or matlab languages will be important.



PIV blood flow analysis in the heart

References

J. M. Taylor, J. M. Girkin, G. D. Love. High-resolution 3D optical microscopy inside the beating zebrafish heart using prospective optical gating. Biomedical Optics Express **3** 3043 (2012).

J. M. Taylor. Optically gated beating-heart imaging. Frontiers in Physiology **5** 481 (2014).

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