# Manual whole slide imaging software utilising open-source computer vision libraries

An RCPA Foundation Grant-In-Aid supported project

We developed software that interfaced with standard microscopes allowing a pathologist to scan a slide in real-time and generate a digitised whole slide image without the need for expensive whole slide scanners or proprietary software.

We achieved this aim using the open-source BoofCV library, modifying algorithms previously described in unmanned aerial vehicle (UAV) mapping of ground targets, to create a real-time image mosaic java app, capable at a minimum of generating 300 megapixel images on a grant provided computer (Core i7, 16GB RAM) and microscope (Phenix BMC500, LED).
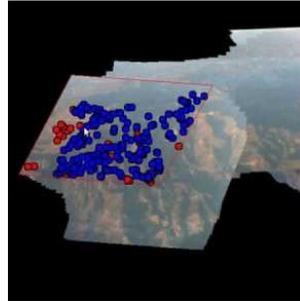
Left: UAV ground mapping. Above: Keratocystic odontogenic tumour captured using algorithms of the same image library.

Initially we utilised the video stream of a smartphone connected to the eyepiece of the microscope. This required modelling a custom 3D printing smartphone to microscope adapter that permitted a wired connection to the host PC for faster data transfer.

We used this method for image analysis published in, **"Prostatic nerve subtypes independently predict biochemical recurrence in prostate cancer. Journal of Clinical Neuroscience. A. Reeves, Fairleigh & Battye, Shane & Roth, Hedley & S. Peters, Justin & Hovens, Chris & J. Costello, Anthony & Corcoran, Niall. (2019)."**
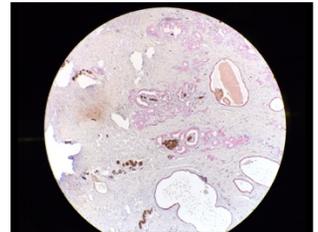

Smartphone generated images for analysis

Using a smartphone for real-time stitching required additional algorithms to correct for illumination unevenness (flat field correction) and lens distortion.

However, this overhead on the CPU is mitigated by using a microscope mounted CMOS camera, attached via c-mount. The optics of this setup presents a near undistorted image frame allowing seamless stitching without the need for additional image correction algorithms. This setup is being used for, **"Histological testis stromal changes in patients undergoing gender reassignment surgery. Battye, Shane & Middleton, Iffy. (2019 Work in Progress)."** and has been published in, "**Ectopic liver attached to a chronically inflamed gallbladder: a rare and surgically challenging combination. Granek, Romy & Battye, Shane. (2018)."** Image on right.
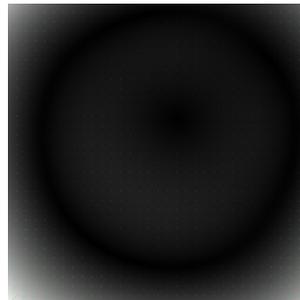
Above: Distortion magnitude analysis of iPhone camera lens; corrected for in software
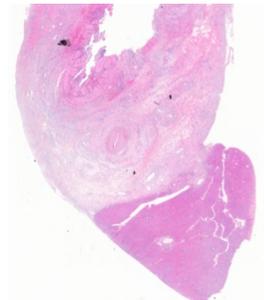
Above: Whole slide scan of ectopic liver on gall bladder utilising the real-time stitching software and CMOS camera

Outside of research, applications of the technology we developed in this project can be found in;
- Telepathology education, Dr Tim Bracey
- Multidisciplinary meeting presentations (see right)

Our work is ongoing and our next steps include applying artificial intelligence for image analysis on images captured by real-time stitching off a microscope.

We would like to sincerely thank the Foundation and RCPA for their support in allowing us to undertake this project.

- Dr Shane Battye FRCPA

Specimen 4: Caecal polyp
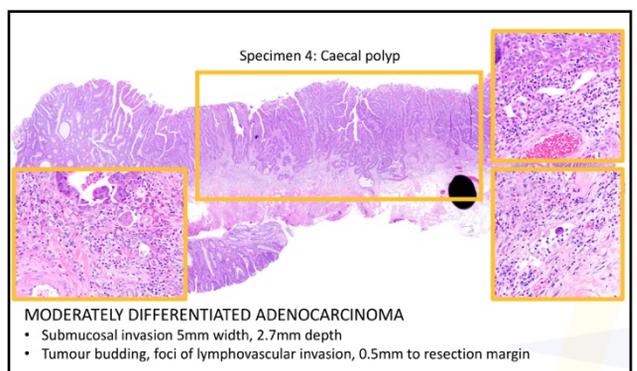
MODERATELY DIFFERENTIATED ADENOCARCINOMA
- Submucosal invasion 5mm width, 2.7mm depth
- Tumour budding, foci of lymphovascular invasion, 0.5mm to resection margin