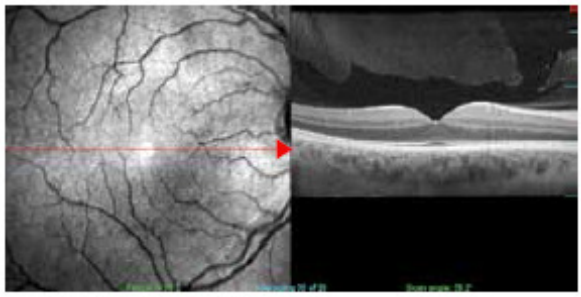
GALAHAD project newsletter #1

July 2017

GALAHAD is a research project supported by the European Commission through Horizon 2020 under Grant Agreement 732613.

Welcome to the first GALAHAD project newsletter!

GALAHAD is a collaborative research project addressing the need for better early diagnosis of glaucoma; a disease which is the second leading cause of blindness after cataracts. GALAHAD aims to improve the axial resolution of optical coherence tomography (OCT) and explore polarisation sensitive applications of OCT in order to develop an early warning glaucoma screening test which can be used by non-expert operators.



This first newsletter will outline the main objectives of the project. Future editions will provide updates on the progress of the work and project-related news and events.

More info is available on the website (www.galahad-project.eu).

GALAHAD paper at 2CCOCT

2CCOCT

- 06-08 Sep-2017
- Canterbury, UK
- http://2ccoct.aogkent.uk/

A paper outlining the objectives of GALAHAD will be presented at the 2nd Canterbury Conference on OCT. A wide range of topics will be covered, many of which are of direct relevance to GALAHAD, including high axial resolution OCT in imaging the eye, supercontinuum sources and polarisation effects in broadband OCT. The conference website summarises some of the challenges in GALAHAD very well:

"This three day conference will be dedicated to recent advances in measurement and imaging conditioned by progress in enlarging the spectrum of the optical source. The larger the bandwidth of the broadband optical source used in spectrometer based OCT, and of the tuning bandwidth of swept lasers used in swept source OCT, the better the axial resolution. However, an increase in the source bandwidth brings with it other problems that the research community have tried to address in the last decade."

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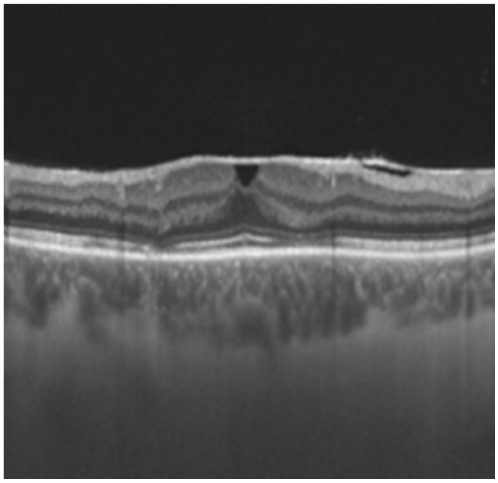
The potential benefits of glaucoma screening

Glaucoma is the second leading cause of blindness globally. The disease is caused by increased intra-ocular pressure resulting in irreversible damage to the optic nerve head (ONH). Systematic in depth ONH diagnostics after a positive glaucoma screening would save 4M cases of blindness *p.a.* worldwide but a cost-effective test is not possible with existing technology.

A leading candidate technology is optical coherence tomography (OCT). OCT is label free and non-invasive and can be realized in compact and easy to handle systems with the potential for a worldwide usable diagnostic approach. However glaucoma screening requires a very high axial resolution for the posterior segment of the eye; perhaps as small as 1 µm. Currently even high quality commercial systems typically achieve *c.* 3-5 µm.



Vertical transfoveal OCT of an eye with epiretinal fibrosis, [Image courtesy of Rigshospitalet (Copenhagen)]

UHR-OCT

GALAHAD will develop ultra-high resolution (UHR-) OCT systems in a very cost-effective manner by using extremely wide bandwidth supercontinuum sources with a tailored Gaussian bandwidth profile together with a range of new low cost component designs (*e.g.* fused devices and delay lines) which are capable of handling this broadband source (up to 300 nm).

PS-OCT

Recently several research groups have shown that polarisation sensitive (PS-) OCT can identify birefringent retinal features which can improve glaucoma diagnosis. GALAHAD will study these features and assess how they can be used to identify the early stages of glaucoma.

Automated algorithms

The third element to the project is to use a combination of clinical assessment and machine learning to analyse both existing data and new UHR- and PS-OCT images to train an automated algorithm to identify the early stages of glaucoma.

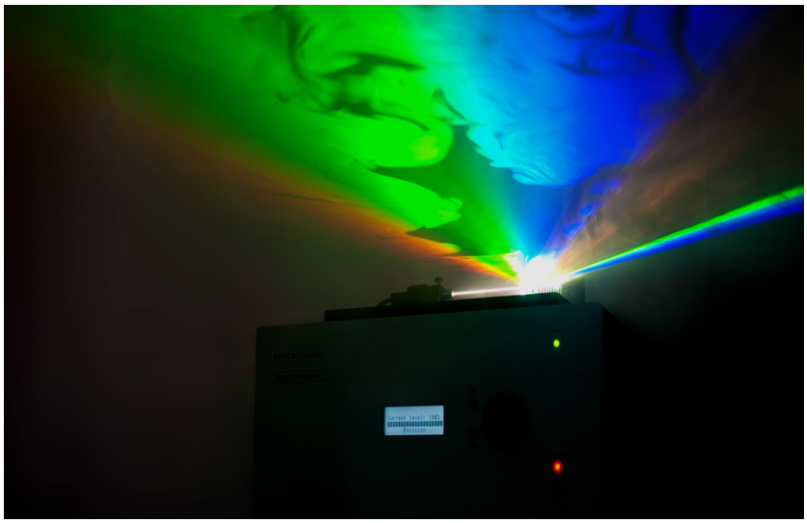
The resulting system will use new multiband imaging modalities based on ultra-high resolution polarisation sensitive OCT (UHR-PS-OCT) and combine new algorithms for image analysis into a compact multimodal system.

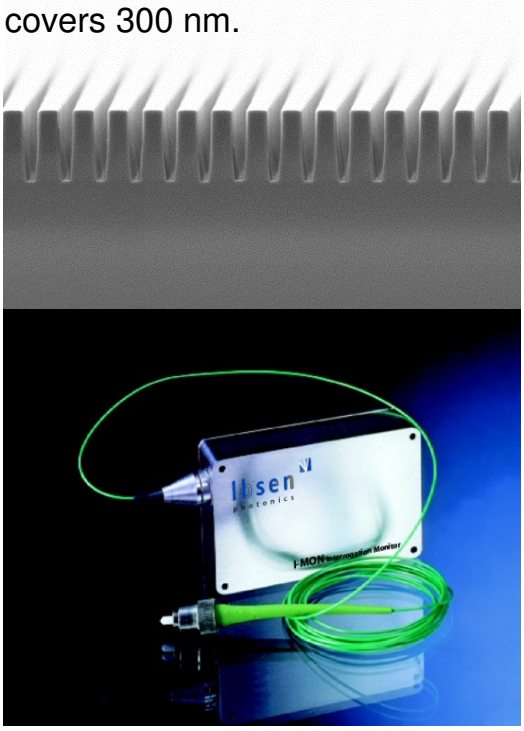
For more info contact Bruce Napier: bruce@vividcomponents.co.uk

Key elements of GALAHAD

Supercontinuum source

The axial resolution of a broadband OCT system is limited by the bandwidth of the illumination source, which should ideally have a Gaussian profile. NKT and DTU will use a novel approach based on pulsed fibre lasers coupled to supercontinuum (SC) generating fibres to build a linearly polarised, ultra-low noise coherence SC source. This source will allow fibre delivery of an output spectrum which covers 300 nm.





Grating and spectrometer

Ibsen core technology is planar, surface relief transmission gratings in fused silica which are produced by holographic or photo-lithographic patterning and reactive ion etching. In GALAHAD Ibsen will work to develop its fundamental grating technology: producing large, high efficiency broadband transmission gratings which are polarisation insensitive and simultaneously reducing the cost of the gratings using novel manufacturing techniques.

These gratings will be used as the basis for a low cost polarisation insensitive broadband spectrometer. This device will be high performance, high resolution, temporally stable, broadband with a small physical size.

Fused fibre components

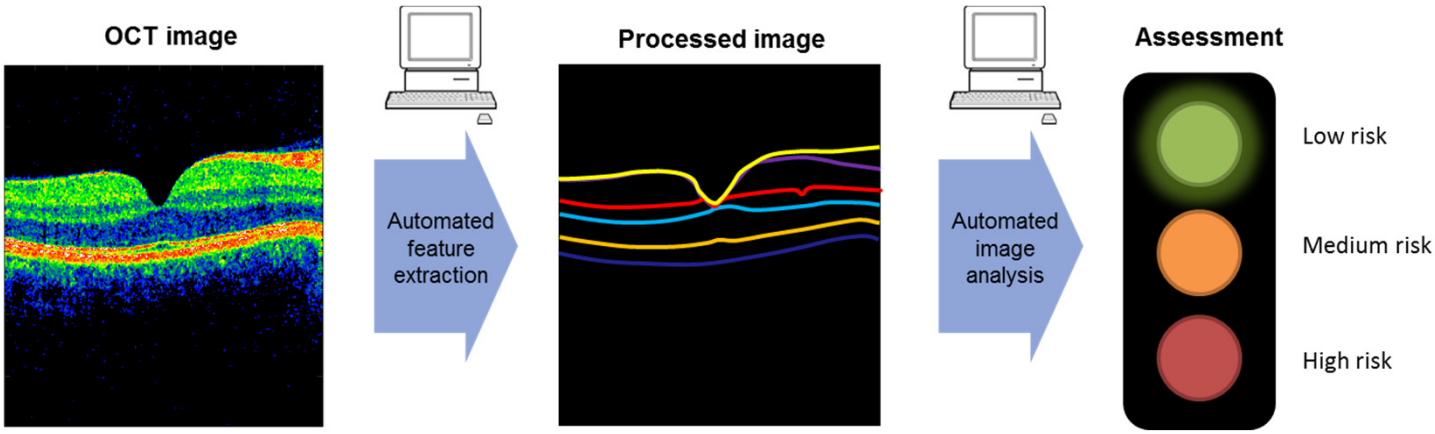
G&H is well-known for its fused fibre coupler technology. These are precision components which split and recombine the radiation into the different fibres of the OCT system. In GALAHAD G&H will develop new coupler designs to accommodate the 300 nm bandwidth signal from the SCS. This will require wavelength-flattened response for both single-mode (SM) and polarisation maintaining (PM) couplers: a huge challenge which will require novel fabrication methodologies and a new coupler work station at the Torquay (UK) site.

Optical delay line

An optical delay line is used in OCT systems to match the reference and sample optical path lengths. For optimum performance, the delay line needs to be dynamically adjusted. This allows for changes in eye position between patients. In GALAHAD G&H will work on new designs for small form factor motorised optical delay lines. These need to be both wideband and PM whilst maintaining high stability and reliability over travel and temperature.

Automated algorithms

Universitat Politècnica de València (UPV) and Gloucestershire Hospitals NHS Foundation Trust (GHNT) are working on the development of retinal layer segmentation algorithms. By looking at existing conventional OCT images the medical and software experts will devise image processing algorithms for significant feature extraction. This algorithm will be refined and tested, as new images from GALAHAD become available, with the objective of the validation of a glaucoma screening algorithm. This process will be automatic, robust and clinically usable by non-expert operators and will provide a “traffic light” output to identify high risk patients for further assessment.



Data collection and demonstration

Rigshospitalet and University of Münster (WWU) will develop test standards including cellular, tissue and animal models for UHR OCT performance analysis and demonstration. These methods will also contribute to the algorithm training. Experts at WWU will perform an experimental characterization of optical tissue properties utilizing OCT and digital holographic microscopy including tissue birefringence properties with polarization sensitive interferometric techniques. In the final stages of the project, the new hardware, software and processes will be demonstrated in two GALAHAD UHR-PS-OCT systems by these two clinical partners with technical support from the whole team.