NOVEL AI APPROACHES IN MEDICAL IMAGE INTERPRETATION

INNOVATION SANDPIT   JANUARY 2019

CANCER RESEARCH UK

EPSRC
Engineering and Physical Sciences Research Council

Science & Technology Facilities Council

Together we will beat cancer

AIMS

As part of Cancer Research UK's (CRUK) wider efforts in bolstering early detection of cancer research, we're bringing together expertise not only from cancer biology, but other disciplines, leveraging the best minds and most novel concepts emerging from chemistry, physics, engineering, mathematics, and computer science. To this end, we are partnering with the Engineering and Physical Sciences Research Council (EPSRC) and the Science and Technology Facilities Council (STFC) to develop new multidisciplinary and revolutionary research ideas.

We united research communities from CRUK, EPSRC, and STFC for the second Early Detection Innovation Workshop from 6-9 January 2019 at The Oxford Belfry, Oxfordshire. Attendees had expertise spanning from astrophysics to clinical research and we've looked at opportunities for cancer early detection using clinical imaging.

The workshop focussed on developing new research ideas utilising emerging technological and methodological insights from computer science, artificial intelligence and image analysis for the interpretation of clinical images, thus providing a novel and innovative approach to detecting cancer early.

Imaging is used as part of the screening programmes for breast and bowel cancers, and second-line imaging techniques, such as MRI, CT and X-ray. They are crucial in screening and diagnosing cancers in patients presenting with vague symptoms, and are particularly pertinent in detecting lung and brain cancers.

In recent years huge advances have been made in the areas of AI. The strength of AI algorithms is the ability to process huge, complex datasets without bias, as well as being able to identify new patterns and features that medical professionals aren't currently looking for, orprovide new information on aggressiveness and likelihood of progression.

There is an opportunity to bring together expertise from these areas with cancer researchers to focus on the interpretation of medical images to accelerate early cancer detection and have a great health economic impact.

Research that will be conducted as a result of this event is relevant to a range of new approaches for early detection of cancer, including (but not limited to):

- Can AI analysis be applied in real time as images are collected?

- Can clinical imaging be used to detect relapse and identify pre-cancerous lesions that will progress to cancer?

- New tools to optimise imaging-based screening tools.

- Evaluating the feasibility of novel imaging technologies in early detection.
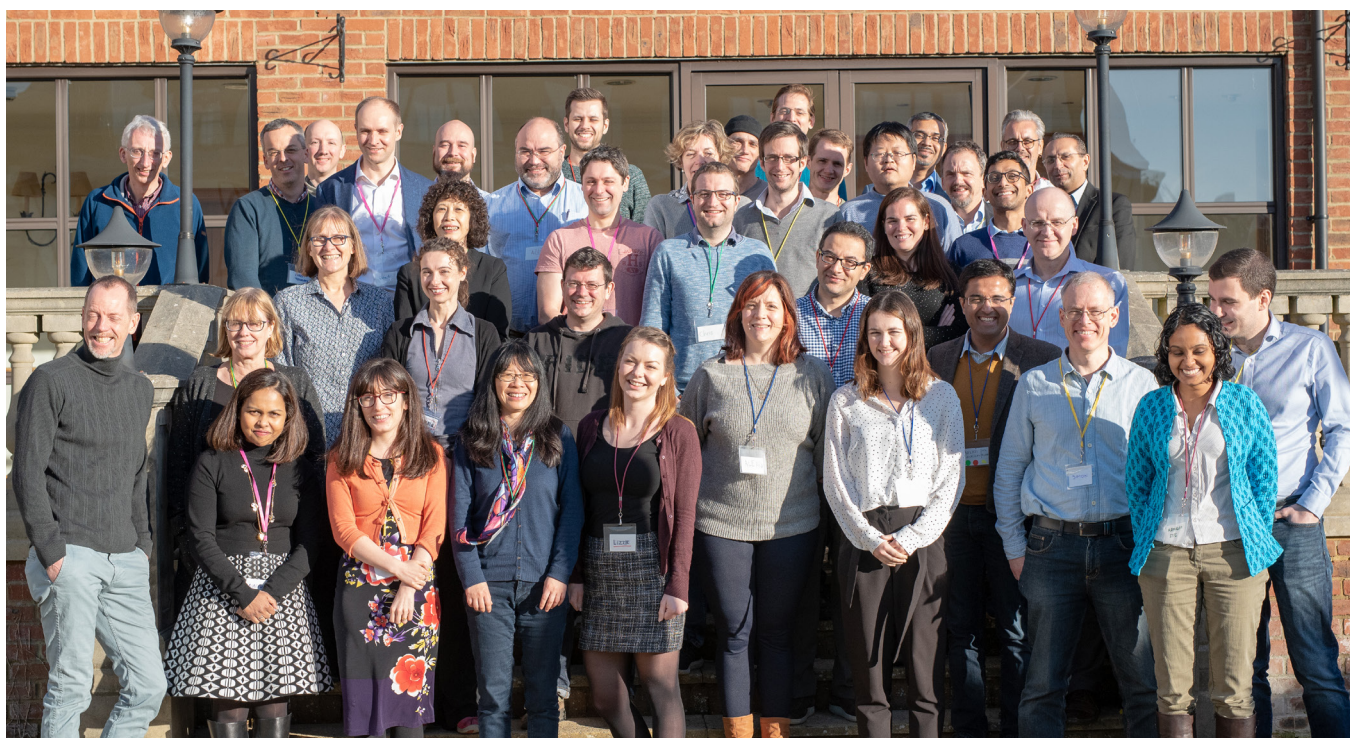
WORKSHOP DIRECTOR

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WORKSHOP SPEAKERS

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Professor Alejandro Frangi
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Professor Nasir Rajpoot
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Professor Evis Sala
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Dr Marnix Jansen
University College London

Professor Bissan Al-Lazikani
The Institute of Cancer
Research and member of
CRUK's Early Detection
Research Committee.

Bissan attended the final
pitches and served on the
funding panel.

FUNDING AWARDED

On the final day of the workshop, each group presented their research idea. The Funding Panel, comprising workshop Director, Mentors, and Bissan, awarded the best proposals up to £100,000 each, to support the subsequent pilot and feasibility studies.

Five projects were funded, commencing on May 2019 for 12 months.

PROJECT 1:

AI-is: AI-informed screening

Group members & Institutions:

Dr Sue Astley, University of Manchester

Dr Adam Brentnall, Queen Mary, University of London

Dr Lucy Warren, Royal Surrey County Hospital NHS Foundation Trust

Dr Gemma Poulter, Science and Technology Facilities Council

Dr Chris Tromans, Volpara Solutions Europe Ltd

Background

Population screening for breast cancer is based on mammography which is low cost, has high throughput, is suitable for the majority of women screened, and has a low rate of recall. However, the sensitivity of mammography is significantly lower in women with dense breasts where cancers may be hidden by overlapping, dense tissue, making early signs of cancer hard to identify.

There is evidence that the use of supplemental imaging modalities such as Automated Whole Breast Ultrasound (ABUS) can improve cancer detection in women with dense breasts. There is a need for a more specific method to identify women for whom the sensitivity of mammography is limited and would benefit from supplemental imaging.

Aim and methodology

We aim to develop a method to analyse mammograms to identify those women who may have difficult-to-detect or masked cancers and who should be offered supplemental imaging. This will improve the cost effectiveness of personalised breast screening by targeting additional screening to women at risk. It may also enable women with dense breasts to benefit from earlier detection of cancer.

To achieve this we will be applying novel, physics-based pre-processing and normalisation to mammograms to generate a model of the lesion. This AI method will aid in identifying women with dense breasts where cancer could be missed with traditional screening approaches.

PROJECT 2:

Predicting the location of lung nodule occurrence from low-dose CT using convolutional time-to-event networks (X-Net)

Group members:

Dr Matthew Blackledge – ICR
Dr Carolyn Horst - UCL
Professor Xujiong Ye – University of Lincoln
Dr Reyer Zwiggelaar – University of Aberystwyth
Dr Balaji Ganeshan – UCL
Dr Richard Lee – Royal Marsden Hospital
Dr Spencer Thomas – NPL Ltd

Background

Lung cancer kills over 35,000 people each year in the UK. More than 70% of patients are diagnosed with late-stage disease that cannot be cured. These statistics could be drastically improved through lung cancer screening programs of patients at risk using low-dose CT (LDCT), yet lung screening is not currently offered in the UK. This is in part due to a lack of optimal screening strategies for individual patients. Whilst good criteria exist for who should be screened, a method for identifying when and how frequently they should be screened is unavailable.

Aim and methodology

Our aim is to develop and test a novel artificial intelligence (AI) architecture that combines baseline LDCT studies with other patient demographic information such as age, smoking status, and smoking history to personalise screening intervals for patients at risk of developing lung cancer.

Our hypothesis is that apparently 'normal' baseline LDCT scan will have certain features, perhaps not visible to the human eye, that can (i) predict time-to-lesion-appearance of lung tumours, and (ii) map where these tumours are likely to occur.

The NHS have committed approximately £70 million to rolling out LDCT lung screening in high-risk localities in the UK. Using our tool, clinicians will be able to decide when to recall patients for screening in order to (i) diagnose lung cancer at the earliest moment ii) reduce patient radiation exposure, and (iii) reduce the costs of screening by avoiding unnecessary scans.

We will use existing publicly available images from the US-led national lung screening trial (NLST) lung cancer screening dataset to identify, model and map a pre-cancerous signature present on baseline LDCT lung scans using our technology.

PROJECT 3:

Endo.AI Real time automated endoscopic detection of oesophageal squamous cell cancer in early and precancerous stages

Group members

Professor Barbara Braden – Oxford University Hospital NHS Foundation Trust
Dr Wei Pang – University of Aberdeen
Stephen Taylor – University of Oxford, Zegami
Professor Xiaohong Gao – Middlesex University

Background

Early squamous oesophagus cancer, worldwide the most common form of gullet cancer, and its premalignant stages are often missed during endoscopy because these lesions are usually flat and differ from normal squamous epithelium only by subtle changes in colour and vascular structure. Early detection, however, is paramount because the cancer is curable as long as the cancer is defined to the superficial lining whilst the prognosis is poor in more advanced stages.

Aim and methodology

We will apply advanced imaging techniques using special dyes or filtering techniques of the light spectrum to improve the detection of early squamous neoplasia in the oesophagus during endoscopy.

We will develop a real-time computer algorithm which can run during the endoscopy exam, highlighting areas of concern and guide the clinician to biopsy these areas.

The Endo.AI project will develop a prototype real-time clinical decision-support system to assist clinicians while performing endoscopic procedures. It will signal the endoscopist to take a biopsy from mucosal areas suspicious for early squamous neoplasia.

The quality of the endoscopy is operator-dependent, based on the experience and expertise of the endoscopist. The AI based prototype will provide standardised automated lesion recognition with high sensitivity, independent of the training of the endoscopist.

PROJECT 4:

EDIFICE - Early Detection of cancer recurrence In patients with glioblastoma using artiFicial IntelligenCE through imaging

Group members & Institutions:

Dr Stuart Currie – Leeds Teaching Hospitals NHS Trust
Dr Ali Gooya – University of Leeds
Dr Patrick Hales – University College London
Dr Spencer Thomas – NPL Ltd

Background

Glioblastoma (GBM) is the most common adult malignant brain tumour. Despite intensive treatment (surgery, radiotherapy and chemotherapy), GBM virtually always recurs. Thus, prediction of recurrence is of paramount importance as it can offer earlier patient therapy and reduce morbidity.

Machine learning has already been shown to help predict survival in patients with GBM based on the imaging characteristics of the tumour prior to treatment, with time-series data further improving this estimation.

Aim and methodology

The time to recurrence in GBM is determined by multiple factors, including extent of surgical resection, tumour location, and tumour biology. In this project, we will incorporate all these data into a computer model for predicting the early spatial and temporal characteristics of tumour recurrence following initial resection.

The results we generate from this feasibility study will lead to further research into personalised treatment where patients can undergo earlier and more targeted therapy. This research may be applicable to other cancers by allowing early detection of secondary tumours in radiotherapy fields.

PROJECT 5:

AI and MR physics simulation to assess low-cost, low-field MRI as a cancer screening tool

Group members:

Dr Matt Hall – National Physical Laboratory

Dr David Atkinson – University College London

Dr Wei Pang – University of Aberdeen

Dr Stuart Currie – Leeds Teaching Hospitals NHS Trust

Dr Ali Gooya – University of Leeds

Dr Simon Doran – ICR

Background

Low field MRI is a potential low cost medical imaging solution for primary cancer screening. Low field scanners are easier to engineer and have lower running costs than conventional clinical MR system. Some currently proposed systems have price points as low as $50,000, placing them within reach of, for example, consortia of GP surgeries, mobile clinics, and care in the developing world. However, images from low-field MR systems are of considerably lower quality than clinical MRI, and radiological expertise is not available outside of major hospitals making interpretation difficult.

Nevertheless, there may be scope to employ low field MRI as a screening tool for early detection of cancer. Following imaging, an AI-based analysis would make a judgement on referral for a conventional clinical scan and, potentially, enhance low-field images to improve their clinical utility and reliability.

Aim and methodology

We will investigate the utility of low-field MRI by training an AI-based system to infer from the low-field images whether a subject should be sent for further follow-up. AI will also be used to infer the appearance of current high-field clinical images at low-fields. We aim to demonstrate that AI-based approaches are useful in screening employing low-cost imaging solutions.

The results generated from our study will be used to inform a further study in which actual low-field MRI is considered for screening purposes by demonstrating the feasibility of using AI-based screening on low-field images. The approaches developed could also be used to improve the design of future low-field MRI systems by optimising image quality within an overall budgetary constraint.