Gynecologic Cancer InterGroup
Imaging & Pathology Brainstorming Day
October 2018  Munich

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Greater Glasgow and Clyde
Disclaimer (Commercial)

• NHS Greater Glasgow and Clyde are a customer of Philips Digital Pathology
• I receive no payment from Philips
Disclaimer (Academic)

• I am a Pathologist

• I am not a
  • Mathematician
  • Data scientist
  • Computer scientist
Precision Medicine (Diagnostics)
Digital Pathology

- Historical
  - Low volume specialist services
  - Intra-operative examinations

- Over the last 2-3 years
  - Move towards a fully digital workflow
  - Up to 12% productivity gains
  - Ability to safely uncouple technical productions and medical reporting
  - Ability to move reporting to areas of stable capacity

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Challenges for Digital Pathology

Data

Magnification

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Google Maps and Digital Pathology

• Zoom and pan technology developed for google maps underpins digital pathology.
• Whole slide image data is huge but data streamed in routine viewing is only a fraction (about 5%).
• For example you don’t download a map of the world to find your way with Google maps.
Data Comparisons

Radiology PACS
• 60 MB Uncompressed per study
• 1MB compressed
• In 10 years, just reached 1 PB (1000 TB)

Digital Pathology
• 1.2 GB per slide
• 7 GB per request
• In 5 years, anticipating at least 5 PB
• Won’t reach steady state until 10-15 years

Overall, data requirements are up to 20 x higher.
Drivers for Digitisation

• Currently NHS Scotland manages 2 million glass slides per year
• Digitisation has been shown to improve efficiency – up to 12%
• Security and accessibility of archive
• Enables innovative models of working
  • Cross boundary work sharing
  • Working off site (other hot site or home)
  • Improved ergonomics
The Facts.....

• 8% Consultant vacancy rate in Scotland
  • 15% UK
  • Brexit

• UK – 32% Consultants are over 55
  • Most to retire within 5 years
  • Approximately 120 per year

• Approximately 50 Trainees qualifying per year
  • 70 shortfall per year
  • 20-30 training posts unfilled
More Facts.....

• Annual increase in demand – 4.5%
  • 2-3% in Scotland
• UK Cancer incidence – up 7% in 10 years
  • Scotland 12%
• 25% increase predicted by 2027
  • Demographic shifts
  • More cancer survivors
And Worse Facts.....

- More MDT meetings
- Explosion of RCPath Datasets
  - 63 Cancer Datasets or tissue pathways
  - And complexity of each one
- Mainstreaming of molecular pathology
  - Reflex
  - Adjuvant
  - Clinical trials
- Molecular MDTs and integrated reporting
Pathology Services

• 10-12% efficiency gain welcomed
• But will not be sufficient for sustainability
Signal → Receiver → Message
Limitations

- Excellent pattern recognition
- Moderately accurate measurements
- Poor quantification
- Often just moderate consistency in diagnosis and grading
• Image is pictoral expression of
  • Genomics
  • Transcriptomics
  • Proteomics
  • Environment
  • Context
  • Time
Digitally Augmented Pathology

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Clinically applicable deep learning for diagnosis and referral in retinal disease

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The volume and complexity of diagnostic imaging is increasing at a pace faster than the availability of human expertise to interpret it. Artificial intelligence has shown great promise in classifying two-dimensional photographs of some common diseases and typically offers excellent performance relative to that of unaided human observers. However, the challenge of reaching this performance at scale is not trivial. In this paper, we describe the development of a clinically relevant deep learning based system for assessing optical coherence tomography (OCT) images to provide real-time expert-level diagnostic support in retinal clinical care. We also report on clinical trials that demonstrate its utility.

Abstract

The International Symposium on Biomimetic Imaging (ISBI) held a grand challenge to evaluate computational systems for the automated detection of macular disease in whole slide images of sentinel lymph node biopsies. The top performing systems were based on convolutional neural networks (CNNs) and achieved high performance, with one system achieving an average AUC of 0.75. This is the first time that a machine learning system has surpassed the performance of a human expert in this domain. The authors of the winning system have shown that CNNs can be used to build high-performance, low-cost systems that can be deployed in real-world settings.

1. Introduction

The clinical utility of pathology is limited by the availability of skilled pathologists to interpret and classify samples. Deep learning has shown great promise in aiding this process by automating the classification of medical images. This can enable the identification of pathological conditions, which can lead to improved patient outcomes and reduced costs for healthcare systems.

Methods

We describe the development of a deep learning system for the automated detection of macular disease in optical coherence tomography (OCT) images. The system was trained on a large dataset of OCT images and was evaluated on a separate test set. The system achieved high performance on both the training and test sets, with an AUC of 0.80 on the test set.

Results

The deep learning system achieved high performance on the test set, with an AUC of 0.80. This is the first time that a machine learning system has surpassed the performance of a human expert in this domain. The authors of the winning system have shown that CNNs can be used to build high-performance, low-cost systems that can be deployed in real-world settings.

Conclusion

The development of deep learning systems for medical image analysis is a promising area of research that has the potential to revolutionize the way we diagnose and treat diseases. However, there are still several challenges that need to be addressed, such as the need for large, high-quality datasets and the development of interpretable models. Despite these challenges, the potential benefits of deep learning in medical imaging are significant, and we can expect to see continued progress in this field in the coming years.
Multi-stranded diagnostic data

1. Pathology
2. Radiology
3. Genomics
4. Transcriptomics
5. Proteomics
The missing piece of the jigsaw

DATA

AI

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Future Diagnostics

• Integration of diverse data sources by AI
  • Pathology *Report* data
  • Pathology *pixel* data
  • Molecular data
  • Clinical data
  • Radiology data

• Use of machine/deep learning to compare this integrated data to patient outcomes and identify patterns for predicting outcome of future patient cohorts.

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Opportunities in Cervical Pathology

• Tumour volume as predictors of lymph node metastasis

Ability to count tumour cells
Opportunities in Endometrial Pathology

- Image analysis can measure
  - Mean nuclear size
  - Nuclear variation
  - Glandular percentage
  - Nuclear density
  - Epithelial density

### Table 1: Level of agreement on tumor grade using 3-tiered system.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>$\kappa$</th>
<th>Strength of agreement [15]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atypical complex hyperplasia</td>
<td>0.258</td>
<td>fair</td>
</tr>
<tr>
<td>FIGO grade 1</td>
<td>0.350</td>
<td>fair</td>
</tr>
<tr>
<td>FIGO grade 2</td>
<td>0.096</td>
<td>poor</td>
</tr>
<tr>
<td>FIGO grade 3</td>
<td>0.647</td>
<td>substantial</td>
</tr>
<tr>
<td>Overall</td>
<td>0.368</td>
<td>fair</td>
</tr>
</tbody>
</table>
Opportunities in Ovarian Pathology

• Association of TIL with clinical outcome
• More consistent scoring with image analysis of immunostained sections
Role for Clinical Trial Group

- Custodians of datasets and images to mine for enhanced diagnostic features
- Implement next generation diagnostics into clinical trials to accurately stratify patients based on morphological and molecular characteristics
- Use digital pathology methods for accurate implementation of companion diagnostics
Conclusions

1. Digital pathology (as a way for pathologists to view images has benefits and is worth doing)
2. Pathology image data is important, and not fully utilised
3. Unlocking the full benefits will require Image Analysis and AI
4. AI is key to future diagnostics integrating pathology and omics data
5. Clinical trials should engage with pathologists to ensure consistent patient selection and stratification for meaningful results