Robotics Technology in Medical Diagnosis and Surgery Applications

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About ASTRI and Me

- **ASTRI** ([www.astri.org](http://www.astri.org))
  - Largest ICT R&D center in Hong Kong
  - 15+ years, 500+ people, 1000+ patents
  - Five technology initiatives (FinTech, Smart City, 5G Networking, Intelligence Manufacturing, Health)

- **Me**
  - Ph.D. in Physics
  - R&D experience in Photonics, Nanotechnology, Computer Vision, Medical Imaging
Align with strong needs for (i) lower healthcare cost, (ii) personalized healthcare service, and (iii) better life quality.

R&D strategy: preventive health monitoring and medical diagnosis, medical computing and data analytics.

Health monitoring devices:
- Pulse oximetry
- Blood pressure
- Blood glucose
- Mood, stress
- Cognition
- Food safety

Medical imaging analytics:
- Digital pathology
- Microbiology
- Video endoscopy
- Optometry
- Cancer screening

Bioinformatics computing:
- Gene sequence analytics
- High content screening

R&D Focus:
- Health device manufacturer
- Medical device manufacturer
- Healthcare service provider
Robotics in Medical Diagnosis - Pathology

Traditional Pathology Diagnosis

Tool: Optical Microscope

Object: Morphology & Color

Sample: Tissue/Cell Slide

Digital Pathology Diagnosis

Source: Leica Microsystems
Two Types of Tele-Pathology Diagnosis

- **Real-Time Remote Microscope Control**
  - Historically first developed (1980s)
  - Manual operation
  - Network bandwidth cause latency
  - Only selected field of views recorded
  - Still in use for certain applications (frozen section, cytology, etc)

- **Scan First, Diagnosis Later**
  - Developed more recently (2000s)
  - Fully automated
  - Technically more challenging (auto focusing, image stitching, data transmission & storage, zoom/pan viewer, etc)
  - Whole slide imaging
  - Current main-stream practice
Background:
Tuberculosis (TB) is an infectious disease and among WHO’s top list:
- 9.6M new case and 1.5M death in 2014.
- 200M smear microscopy test annually
- Manual diagnosis with low sensitivity (~ 60%)

Table II.3. Grading scales for bright field (Ziehl-Neelsen) and fluorescence microscopy

<table>
<thead>
<tr>
<th>Union / WHO scale</th>
<th>Bright field (1000x magnification; 1 length=2cm=100 HPF)</th>
<th>Fluorescence (200-250x magnification; 1 length=30 fields=300 HPF)</th>
<th>Fluorescence (400x magnification; 1 length=40 fields=200 HPF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000x field=HPF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Result</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Zero AFB / 1 length</td>
<td>Zero AFB / 1 length</td>
<td>Zero AFB / 1 length</td>
</tr>
<tr>
<td>Scanty</td>
<td>1-9 AFB / 1 length or 100 HPF</td>
<td>1-29 AFB / 1 length</td>
<td>1-19 AFB / 1 length</td>
</tr>
<tr>
<td>1+</td>
<td>10-99 AFB / 1 length or 100 HPF</td>
<td>30-299 AFB / 1 length</td>
<td>20-199 AFB / 1 length</td>
</tr>
<tr>
<td>2+</td>
<td>1-10 AFB / 1 HPF on average</td>
<td>10-100 AFB / 1 field</td>
<td>5-50 AFB / 1 field</td>
</tr>
<tr>
<td>3+</td>
<td>&gt; 10 AFB / 1 HPF on average</td>
<td>&gt;100 AFB / 1 field</td>
<td>&gt;50 AFB / 1 field</td>
</tr>
</tbody>
</table>

HPF = high-power field; AFB = acid-fast bacilli.
Capsule Endoscopy for Small Intestine Diagnosis

- average human GI tract length: 10m
- average capsule travel time: 8h
- capsule video rate: 2fps
- total images to review: 57,600

So again tedious and labor intensive work for endoscopists!

Our solution: **Deep Learning Computer Vision**
Capsule Video Endoscopy Technology

Commercially

- First developed by Given Imaging (PillCam) in early 2000s
- Currently three types of PillCams (initially for small intestine, later added esophagus, then added colon)
- Given Imaging sold over 1M units globally by now
- Several companies offer similar products on market with similar specs
- Capsule propagates in GI tract only by natural peristalsis
- Capsule only provides visual diagnosis function

R&D

- Multifunction capsule (drug delivery, biopsy, therapy, etc)
- Active locomotion control
We aim to develop a compact and affordable capsule localization and navigation system to enable automated free stomach diagnosis with attractive features:

- operator free
- stomach panoramic imaging
- gastric mucosa 3D reconstruction
- photo treatment for Helicobacter pylori
Surgical Robots: Safer, Smaller, Smarter

II. SURGICAL ROBOTS: PAST AND PRESENT

This section follows the evolution of surgical robots. From one generation to the next, invasiveness and collateral tissue damage is reduced while surgical dexterity is augmented.

Ref: Bergeles and Yang, IEEE Transactions on Biomedical Engineering, 2014
Conclusion with Personal Views

- The “intelligence” of medical robotics lags far behind industry/consumer peers
- Computer vision technologies are critically needed
- Value proposition needs to be considered
- Huge opportunity
End of Presentation

Thank you. Questions are welcome.

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