Artificial Intelligence and Robotics in Endoscopy: Current and Future Perspectives

Lenos Archer-Diaby
Editorial Assistant

PRECISION when imaging or performing minor surgical tasks is crucial for all endoscopists. The progresses in artificial intelligence (AI) and collaborative robots will undoubtedly be key in helping surgical practices move towards a higher level of accuracy. Presented at the special symposia 'AI and Robotics in Endoscopy: Hype or Reality?' at the United European Gastroenterology (UEG) Week 2020, Prof Philip Wai Chiu, The Chinese University of Hong Kong, Shatin, Hong Kong, shared his assessment of the current status of this technology and the outlook for the future.

MAN VERSUS MACHINE

Prof Chiu introduced the topic by explaining that "when we talk about AI, we always face the challenge of it being posed as man versus machine; however, I believe that the application of AI should be in collaboration with clinicians and endoscopists." He went on to express his hope that over the next 20 years, the efficacy and quality of diagnostic endoscopy will improve, predicting that robotics will be increasingly applied to enhance its therapeutic potential.

RECENT ADVANCES IN ARTIFICIAL INTELLIGENCE FOR ENDOSCOPY

The current development of AI in endoscopy is focussing on the standardisation of endoscopic examination, detection, and characterisation of gastrointestinal (GI) pathology. The human brain's performance can be altered by stress, fatigue, and limited experience. AI technology can compensate these limitations, decrease interoperator variability, enhance accuracy of diagnosis, and reduce the time, cost, and burden of endoscopic procedures.

Artificial Intelligence in Endoscopic Examination: Cerebro

Prof Chiu proceeded to explain that his institution, in collaboration with the start-up company Endovision (Hong Kong, Hong Kong), has developed a standardised AI-driven protocol for endoscopic examination entitled Cerebro, which provides enhanced screening and surveillance adherent to standard protocols.[1] Clinical trials of Cerebro examined the efficacy of application of the AI-driven assistance device to examine the GI tract (oesophagus, stomach, duodenum). The AI in the protocol has standardised the capturing of imaging and timing for the examination of each of the positions; therefore, if any position is missed the system will alert the endoscopist. Results

"I believe that the application of AI should be in collaboration with clinicians and endoscopists"

from 100 patients have shown a 95% accuracy with high sensitivity (95%) and specificity (95%), and 100 more patients are in the study pipeline. The AI of Cerebro can be regarded as an inspection completeness and quality control tool that ensures an endoscopic procedure is performed with the highest quality, and provides an example of the collaboration AI could offer.

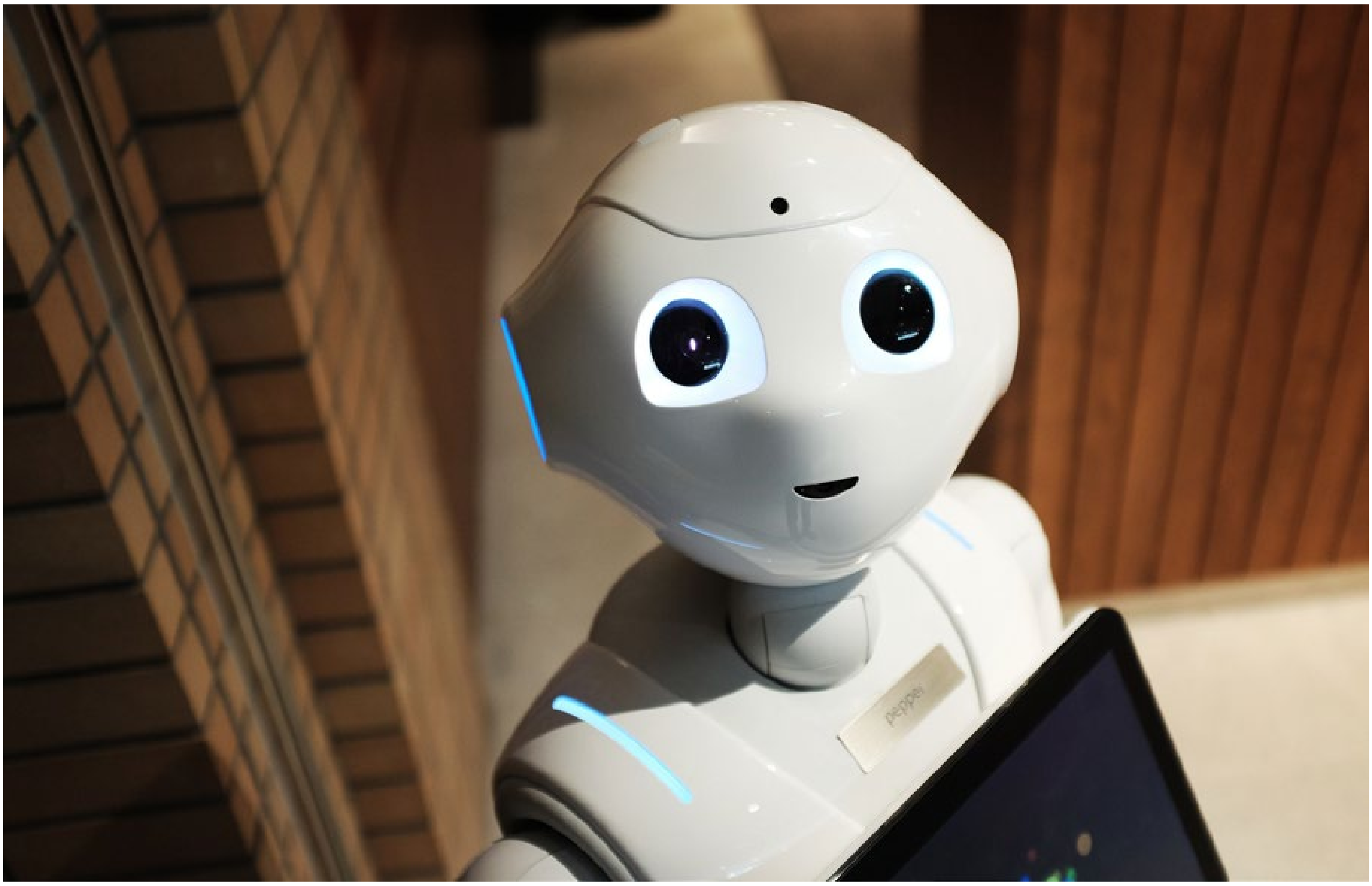
Artificial Intelligence in Endoscopic Detection: ENDOANGEL

Another AI protocol being applied clinically is the ENDOANGEL system (Wuhan, China) for the detection of GI pathology. The ENDOANGEL system utilises deep neural networks and perceptual hashing. In a recent study, patients aged 18–75 years (N=704) were assigned 1:1 to either the ENDOANGEL system (n=355) or unassisted colonoscopy (control; n=349). The results showed that the primary endpoint of adenoma detection rate was significantly greater in the ENDOANGEL group compared with the control group: 16% of 355 patients allocated ENDOANGEL-assisted colonoscopy had ≥1 adenoma detected compared with 8% in the 349 patients assigned to the control colonoscopy group (odds ratio: 2.30; 95% confidence interval: 1.40–3.77; p=0.0010).[2]

Artificial Intelligence in Endoscopic Characterisation: EndoBRAIN

The recently approved AI-assisted system EndoBRAIN has been shown to significantly improve the specificity and sensitivity in GI neoplasia diagnosis. In a Japanese multicentre study between 2017 and 2018, the EndoBRAIN system was trained using 69,142 endocytoscopic images, taken at 520x magnification, from patients with colorectal polyps who underwent endoscopy at five academic centres in Japan.[3] Retrospective, comparative analysis of the diagnostic performance of EndoBRAIN versus 30 endoscopists (20 trainees and 10 experts), in the ability to distinguish neoplasmatic from non-neoplasmatic tumours, highlighted that across all the results (sensitivity, specificity, accuracy, positive predictive value, and negative predictive value), EndoBRAIN had a much better diagnostic accuracy (96.9%, 94.3%, 96.0%, 96.9%, and 94.3%, respectively) compared with the trainees.[3] However, compared with the experts, only the sensitivity and negative predictive value of EndoBRAIN were significantly higher and all other values were comparable.

When questioned on how this technology could be used clinically, Prof Chiu responded that it is important to maintain collaboration between machine and humans. He believes that within their training period, trainees would still require



a mentor but that the AI system could provide telementoring for continuation of observation and guidance and enable the trainees to achieve a high diagnostic yield. This technology has now been authorised for clinical use by the Japanese regulatory agency and in a collaborative manner is assisting doctors in detecting lesions in the clinical setting.

Prof Chiu emphasised: "With this increasing application of AI detection and characterisation, I believe that there is a much higher demand for therapeutic endoscopy."

"In the future, I believe that the robotic technology will be combining with AI to increase the detection of early GI neoplasia"

RECENT ADVANCES IN ROBOTICS FOR ENDOSCOPY

The last 40 years have shown an increasing development in therapeutic endoscopy, including endoscopic mucosal resection (EMR), endoscopic submucosal dissection (ESD), natural orifice transluminal endoscopic surgery (NOTES), and peroral endoscopic myotomy (POEM). Similar to robotic-assisted surgery, robotics in endoscopy are being developed to enhance the interventional capabilities of endoscopists. Currently, robotics are capable of/assisting in polypectomy, mucosectomy, and ESD, with the latter technique being the most suitable to become the gold standard for endoscopic robotics.[4]

Robotics and Endoscopic Mucosal Resection: EndoMaster

The performance of ESD for early GI cancers allows for local, curative-intent treatment; organ preservation, including preserved organ function, fewer postgastrectomy syndromes, and improved quality of life; as well as better postoperative outcomes, such as decreased hospital stay and early return of GI function. However, the performance of ESD is particularly challenging because of the design and use of the endoscopic knife attached to the *"with the use of AI technology combined with the recognition of imaging, we will be able to automate some of the endoscopic procedures for ESD"*

endoscope. On the other hand, the lessons we have learned from the use of robotics in general surgery have provided hope that the quality of dissection can be enhanced with robotic surgery.

With this in mind, the endoscopic robotic platform EndoMaster (Master And Slave Transluminal Endoscopic Robot) was developed by Prof Chiu's team in collaboration with researchers at Nanyang Technological University and National University Singapore, Singapore. The EndoMaster consists of two robotic arms attached to a conventional endoscope and, in 2012, was tested on five patients to perform the submucosal dissection portion of ESD. The EndoMaster was successful in all five patients and complete resection was completed in a short period of time, on par with that seen in similar cases performed through standard ESD techniques.

EndoMaster EASE

Limitations of EndoMaster led to the development of the second-generation EndoMaster Endoluminal Access Surgical Efficacy (EASE) system, which includes an independently designed flexible robotic platform, built-in endoscopic imaging system, independent water-jet system, and a channel passage to extrude and retract the two robotic arms.

This new system differs from conventional ESD as the versatility of movement the robotic arms provide allows for lifting and visualisation of the submucosa, making the system more stable. Currently, the EndoMaster EASE System is the first robotic-assisted system that can effectively remove GI tumours endoscopically without the need for surgical incisions.[5] The clinical trial for EndoMaster EASE for the treatment of patients with colorectal neoplasms started in May 2020 and is estimated to be completed by December 2021.[6] If approved, the system would enable minimally invasive surgery in the body with increased precision and reduced surgery time, and spearhead the future of robotic surgery.

FUTURE OUTLOOK

Prof Chiu went on to explain that this robotic technology can be used in the future to enhance endoscopic suturing, especially in the confined GI lumen. The technology may potentially also be clinically applied in GI emergencies, such as bleeding ulcers, GI fistula/perforation, and anastomotic leakage. The utility further extends to cases of morbid obesity and can aid in endoscopic sleeve gastrectomy and the management of pouch dilation.

"In the future, I believe that the robotic technology will be combining with AI to increase the detection of early GI neoplasia. Then we will be able to apply more of the endoluminal robotics for the treatment of GI neoplasia," Prof Chiu stated. He further imagines that eventually "with the use of AI technology combined with the recognition of imaging, we will be able to automate some of the endoscopic procedures for ESD." In his concluding remarks, Prof Chiu echoed that AI and future improvements towards three-dimensional and 4K imaging in robotic endoscopy and novel devices for suturing and dissecting will yield tremendous developments in endoscopic surgery.

References

1. EndoVisionAI. Artificial intelligence in the upper-GI endoscopy. 2020. Available at: https://endovisionai.com/. Last accessed: 11 January 2021.
2. Gong D et al. Detection of colorectal adenomas with a real-time computer-aided system (ENDOANGEL): a randomised controlled study. Lancet Gastroenterol Hepatol. 2020;5(4):P352-61.
3. Kudo SE et al. Artificial intelligence-assisted system improves endoscopic identification of colorectal neoplasms. Clin Gastroenterol Hepatol. 2020;18(8):1874-81.
4. Boškoski I, Costamagna G. Endoscopy robotics: current and future applications. Dig Endosc. 2019;31(2):119-24.
5. Endomaster Pte Ltd. Robotic-assisted endoscopic surgery. 2020. Available at: http://www.endomastermedical.com/. Last accessed: 11 January 2021.
6. Chinese University of Hong Kong. EndoMaster EASE system for treatment of colorectal lesions (MASTERCESD). NCT04196062. https://clinicaltrials.gov/ct2/show/NCT04196062.