North Carolina Society of Gastroenterology 2024 Annual Meeting

NORTH CAROLINA SOCIETY OF GASTROENTEROLOGY

BACK TO THE FUTURE OF GI ENDOSCOPY: ARTIFICIAL INTELLIGENCE, THE NEXT FRONTIER?

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Joint Providership

American Society for Gastrointestinal Endoscopy

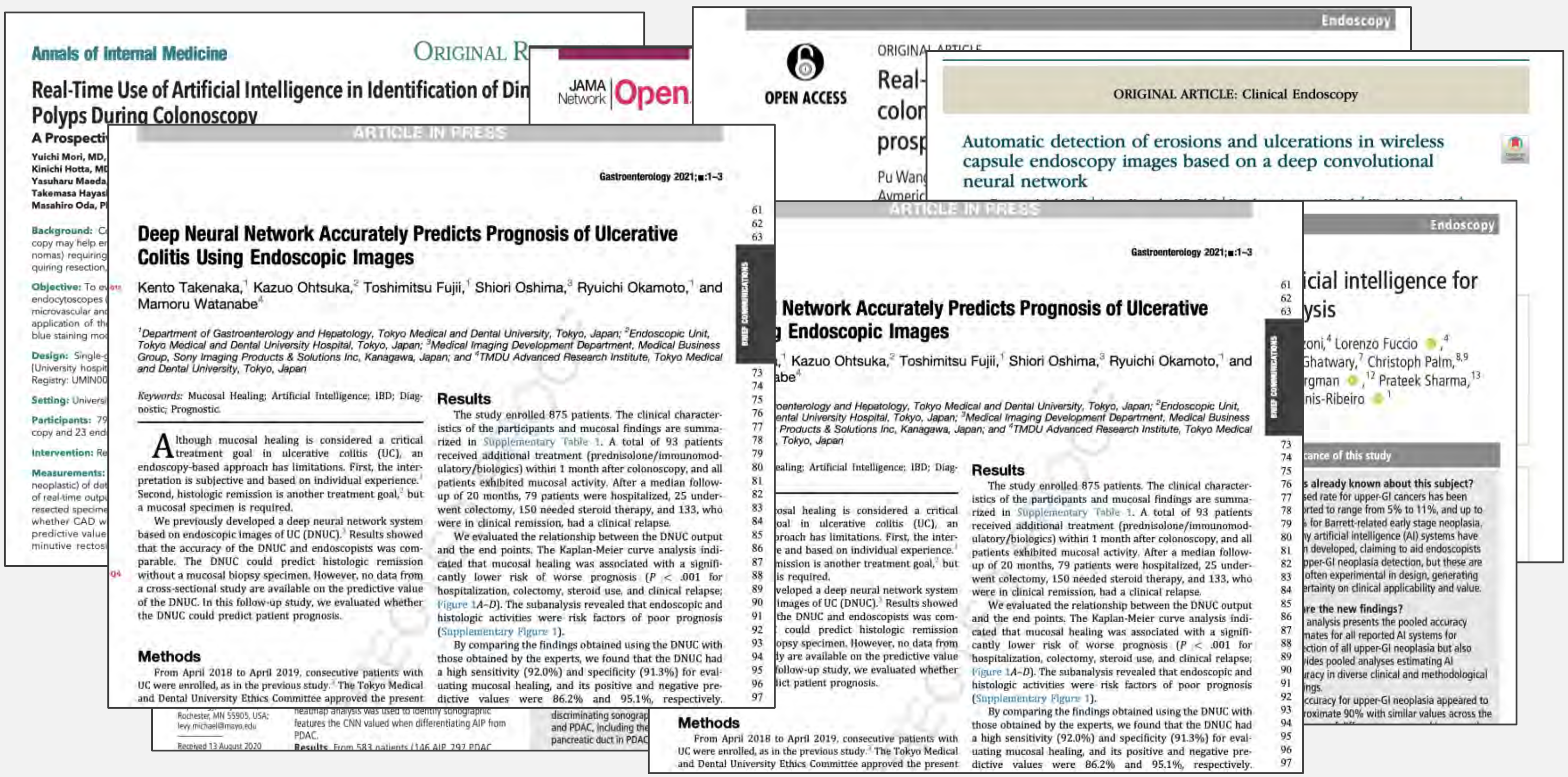
Disclosures

- Consultant for Medtronic
- Consultant for Olympus

Learning Objectives

- Summarize advances in artificial intelligence in the field of endoscopy and how they can be applied to current clinical practice

Why is This Important?



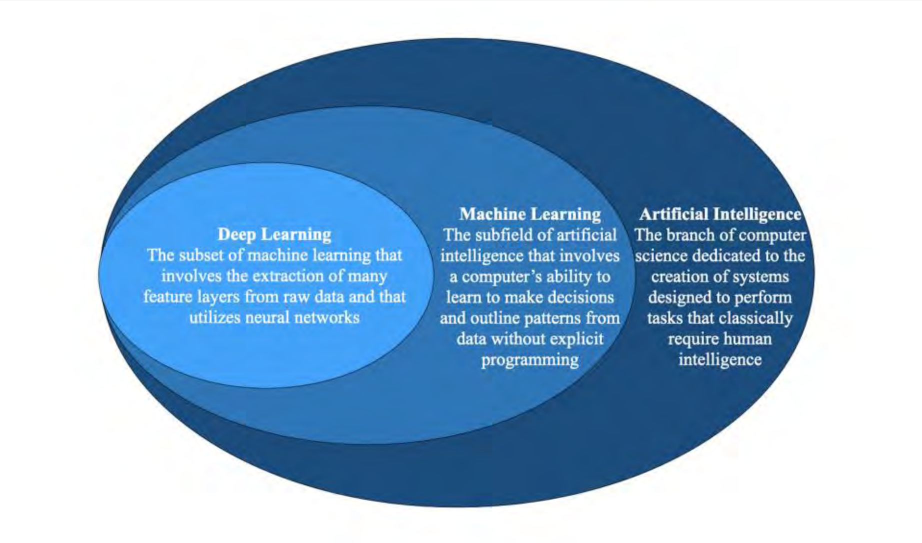
Common Terminology in AI Research

Artificial Intelligence: computer systems that can perform tasks that normally require ‘human intelligence’. Examples: visual perception, speech recognition, natural language processing, self-driving cars

Machine learning: A set of computational methods that involves using mathematical models to learn to make decisions and outline patterns from data. Examples: Linear regression, boosted trees, random forests, support vector machines

Deep learning: A subset of machine learning that relies on multi-layered neural networks to extract information from multiple feature inputs to learn from complex inputs

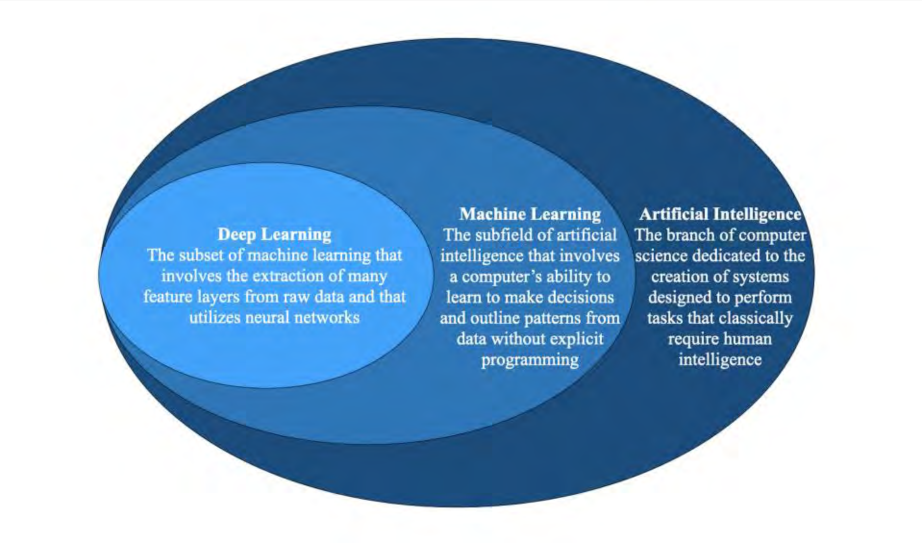
Computer vision: technology that allows computers to “see” and interpret visual content (photos, video)



Common Terminology in AI Research

Large Language Model: Models that process vast amounts of text data (usually scraped from the internet)

- Usually transformer architecture
- ”Generative.” Take an input text → predict the next word/token
- Adaptable



Why Now? (2012-Present)

- Tremendous growth in computational power
- Availability of big data
- Advanced machine learning algorithms

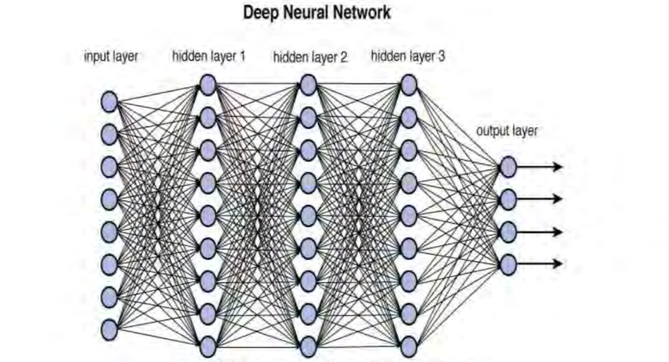
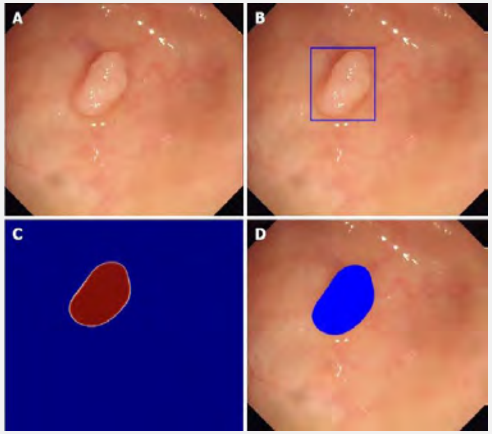
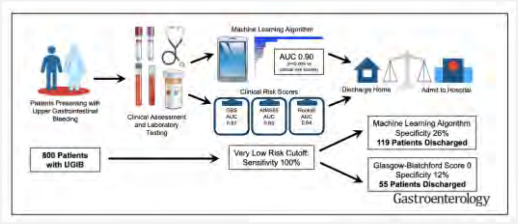


Figure 12.2 Deep network architecture with multiple layers.

Applications



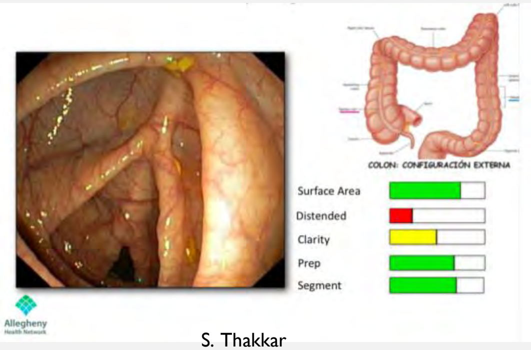
Computer-aided detection (CADe)



Predictive Modeling

Computer-aided diagnosis (CADx)

Endoscopic Quality Assessment



S. Thakkar

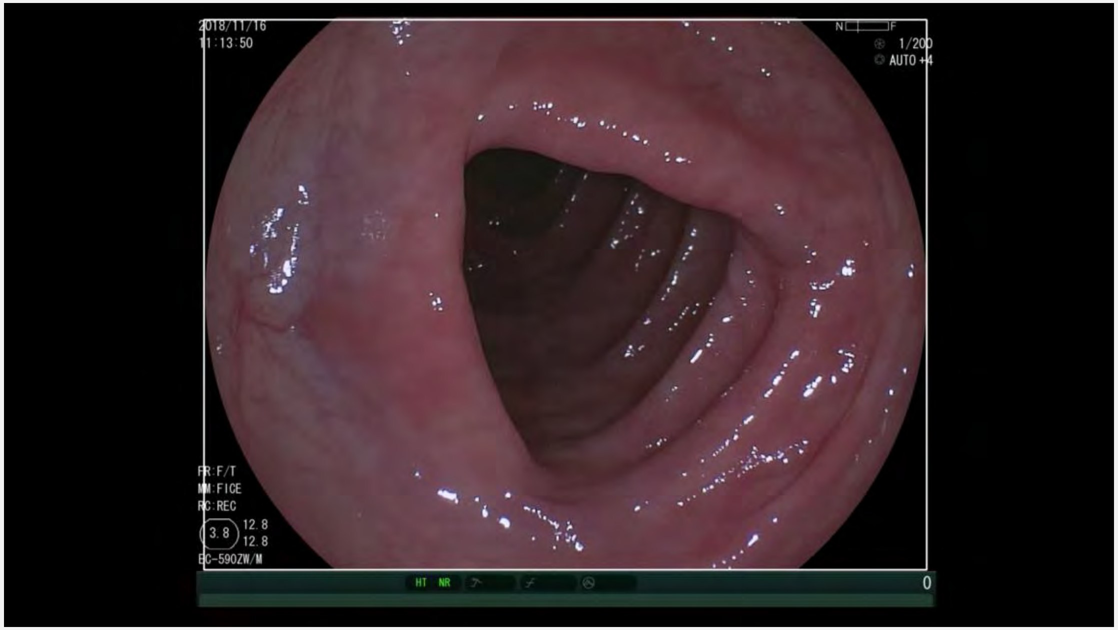
AI assisted reporting/analytics

Ambient Clinical Intelligence

Computer Aided Detection

- The most 'advanced' application of AI
- Several FDA approved CADe systems in the U.S.
- Near-real time delineation of polyps during colonoscopy

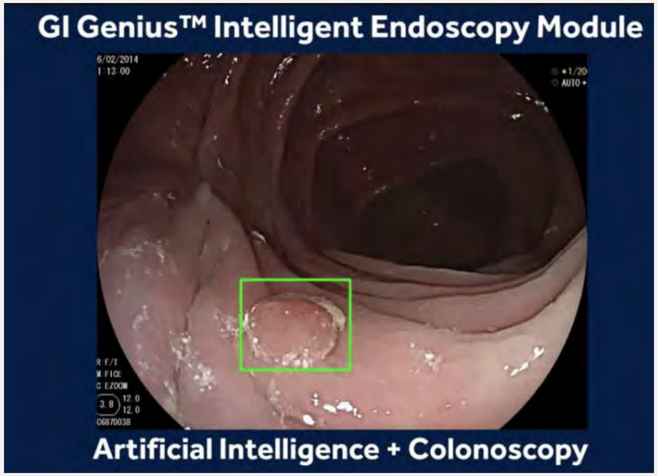
Repici et al. Gastroenterology 5/3/20; 512-520.E7

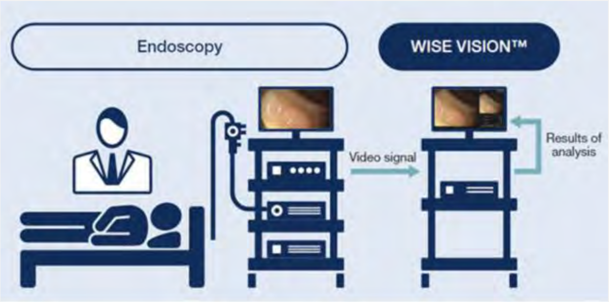


Glissen Brown et al. VideoGIE. 4/2020; P135-137

Computer Aided Detection

- GI-Genius, Medtronic, Minneapolis, MN
- Endoscreener Wision, AI, Shanghai, China and Micro-Tech Endoscopy, Ann Arbor, MI
- Magentiq-Colo, Magentiq EYE LTD, Haifa, Israel
- SKOUT, Iterative Health, Cambridge MA USA and Provation, Minneapolis, MN
- More pending





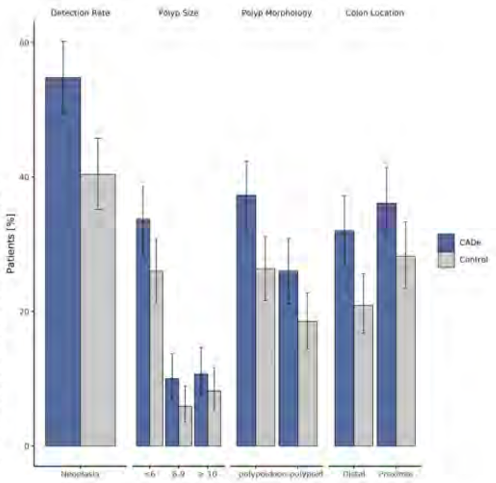
The Evidence

Efficacy of Real-Time Computer-Aided Detection of Colorectal Neoplasia in a Randomized Trial

Alessandro Repici,[1] Matteo Badalamenti,[1] Roberta Maselli,[1] Loredana Correale,[1] Franco Radaelli,[2] Emanuele Rondonotti,[2] Elisa Ferrara,[1] Marco Spadaccini,[1] Asma Alkandari,[3] Alessandro Fugazza,[1] Andrea Anderloni,[1] Piera Alessia Galtieri,[1] Gaia Pellegatta,[1] Silvia Carrara,[1] Milena Di Leo,[1] Vincenzo Craviotto,[1] Laura Lamonaca,[1] Roberto Lorenzetti,[4] Alida Andrealli,[2] Giulio Antonelli,[4] Michael Wallace,[5] Prateek Sharma,[6] Thomas Rosch,[7] and Cesare Hassan[4]

- 685 patients undergoing screening, surveillance, or diagnostic colonoscopy across 3 endoscopy centers in Italy
- Patients randomized 1:1 to receive HDWL colonoscopy or AI-assisted colonoscopy (single screen)
- Significant increase in ADR (54.8% vs 40.4%) with a relative risk of 1.30 (95% CI, 1.14–1.45
- Higher APC
- No significant difference in withdrawal time or resection for FPs

Figure 3. (Per-patient) Adenoma detection rate as well as (Per-patient) ADR by adenomas features. (*A*) Adenoma Size Category, large (≥10 mm) vs small (<10 mm). (*B*) Adenoma Morphology, polypoid: (pedunculated [0–1 p], sessile [0–1 s] or mixed [0–1 sp]) vs non-polypoid lesions: (superficial slightly elevated [IIa], flat [IIb], superficial depressed [IIc], and excavated [III] types). (*C*) SSLs. (*D*) Colon location, proximal colon (cecum, ascending, and transverse) vs distal colon (descending, sigmoid, and rectum). The *asterisk* indicates statistically significant difference between the 2 arms.



Repici et al. Gastroenterology. 5/2020; 512-520.E7

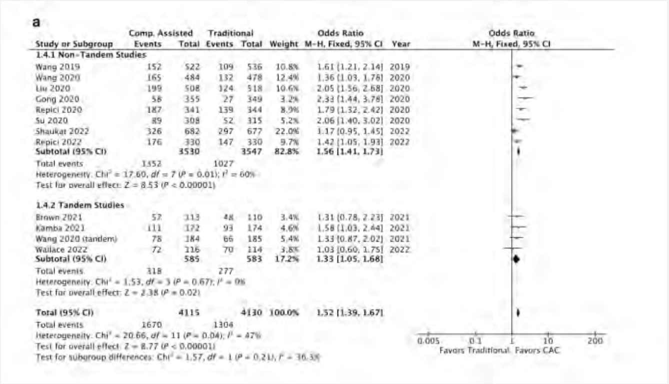
The Evidence

META-ANALYSIS

Effect of computer-aided colonoscopy on adenoma miss rates and polyp detection: A systematic review and meta-analysis

Sagar Shah,* Nathan Park,[†] Nabil El Hage Chehade,[‡] Anastasia Chahine,[†] Marc Monachese,[†] Amelie Tiritilli,[†] Zain Moosvi,[§] Ronald Ortizo[†] and Jason Samarasena[†]

*Department of Internal Medicine, University of California Los Angeles Ronald Reagan Medical Center, Los Angeles, [†]H. H. Chao Comprehensive Digestive Disease Center, University of California Irvine Medical Center, Orange, California, [‡]Division of Internal Medicine, Case Western Reserve University MetroHealth Medical Center, Cleveland, Ohio, and [§]Division of Gastroenterology, Hepatology and Nutrition, University of Pittsburgh, Pittsburgh, Pennsylvania, USA



- Meta-analysis of 14 RCTs containing 10,928 patients
- 52% increase in ADR in CADe vs. control (OR, 1.52; 95% CI, 1.39–1.67, P = 0.04, I2 = 47%).
- 65% reduction in AMR (OR, 0.35; 95% CI, 0.25–0.49, P < 0.001, I2 = 50%)
- 93% increase adenomas > 10 mm de- tected (OR 1.93; 95% CI, 1.18–3.16, P < 0.01, I2 = 0%).
- Decrease in SSLMR

Shah et al. Journal of Gastroenterology & Hepatology 11/9/2022 Nov 9.

Tips and Tricks

Figure 2. An example of a single monitor setup, where computer-aided detection output is displayed on the primary endoscopy screen. (Image ©2020 Medtronic. All rights reserved. Used with the permission of Medtronic.)

Bilal et al. Am J Gastroenterol 7/2020; 115(7):963-966.

Tips and Tricks

Using Computer-Aided Polyp Detection During Colonoscopy

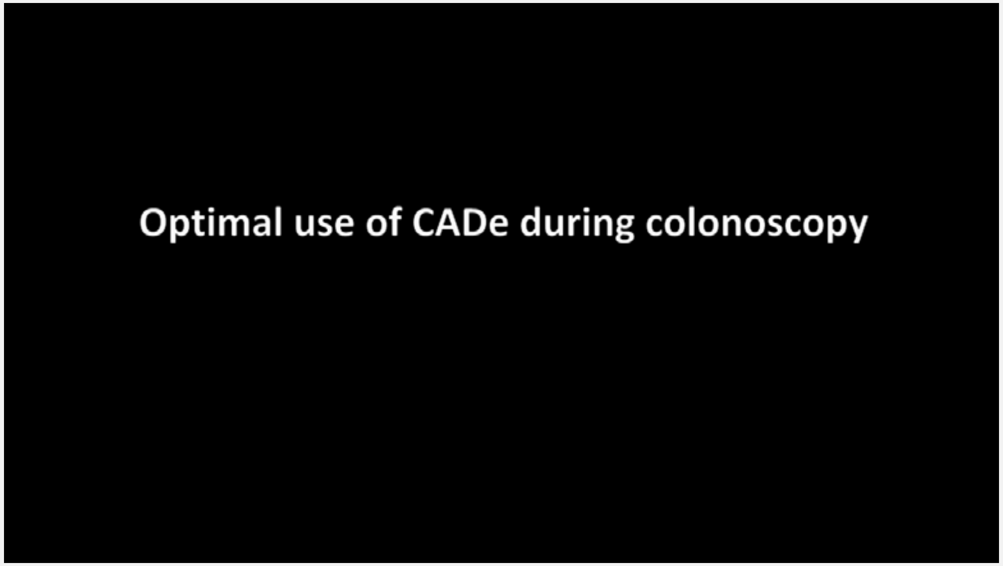
Mohammad Bilal, MD[1], Jeremy R. Glissen Brown, MD[1] and Tyler M. Berzin, MD, FASGE, FACG[1]

Am J Gastroenterol 2020;115:963–966. https://doi.org/10.14309/ajg.0000000000000646; published online May 13, 2020

- Mucosal inspection techniques paramount
- Toggle on during withdrawal after cleaning
- Limit bubbles, suction polyps
- Toggle on during tool deployment but off during intervention

Bilal et al. Am J Gastroenterol 7/2020; 115(7):963-966.

Tips and Tricks

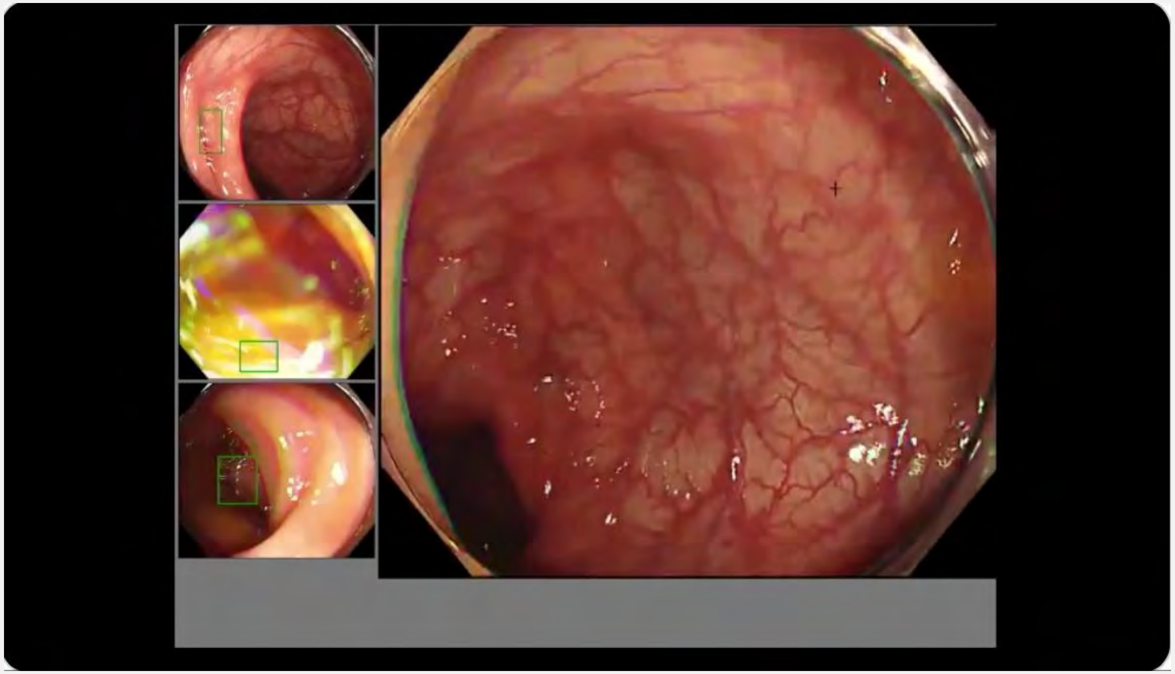


Glissen Brown et al. VideoGIE. 4/2020; P135-137

Questions and Controversies in CADe

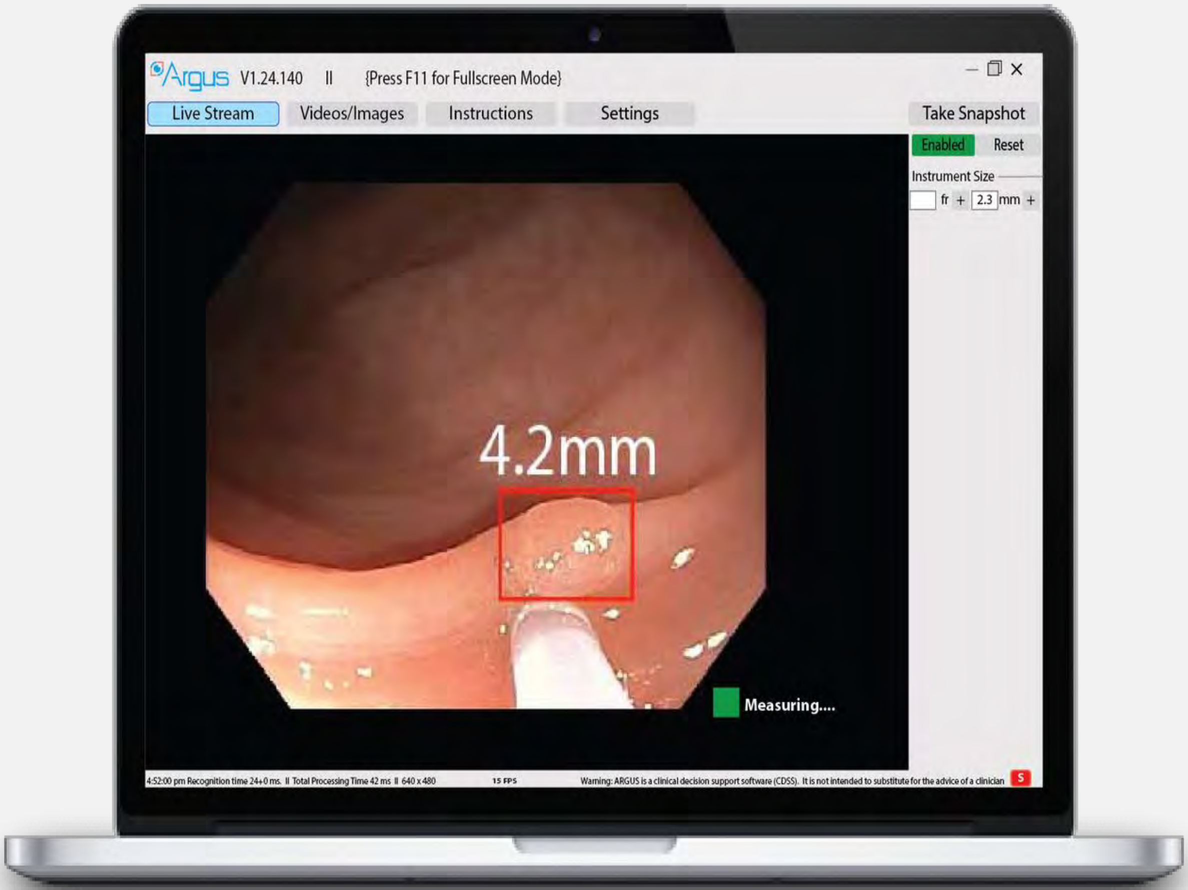
- Hold outs and delayed uptake
- Question of de-skilling and CADe in the training curriculum
- Lack of benefit in some trials (see above)
- Task specific "AI" sows doubt
- Cost

Future Directions: Combined Systems



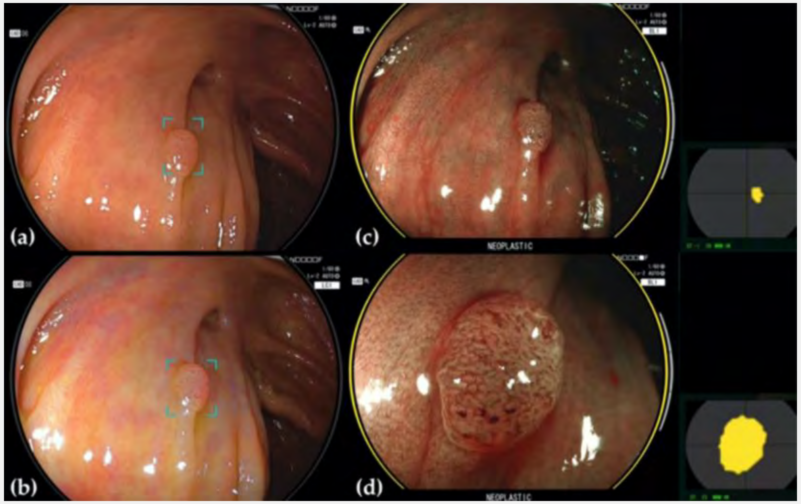
Video Credit: https://lpixel.net/

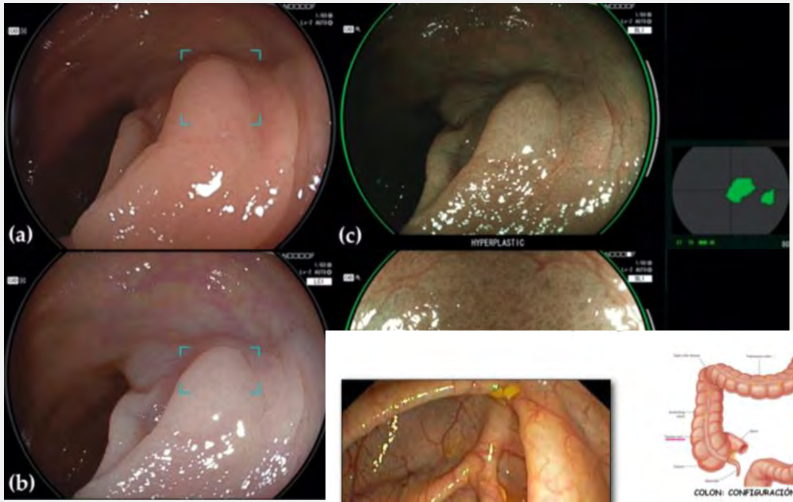
Future Directions in Colonoscopy

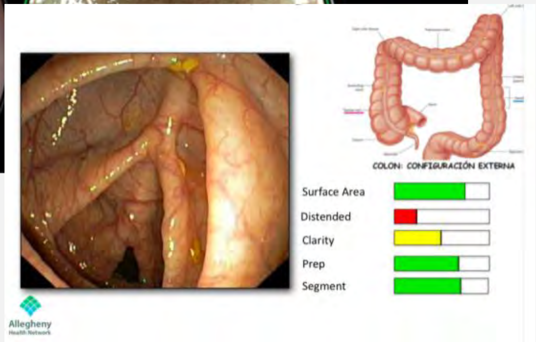


Images courtesy of EndoSoft

Future Directions in Colonoscopy







Kamitani et al. J Clin Med. 2022 May 22;11(10):2923
Image courtesy of Dr. Shyam Thakkar and Allegheny Health Network

Other Applications of CADe/CADx

- CADe/CADx for detection of UGI malignancies and BERN (*Arribas et al Gut 2020*)
- CADx for pathology slides (*Iizuka et al. Sci Rep 2020*)
- VCE: Automatic detection of protruding lesions, flat lesions, CeD, parasites (*Saito GIE 2020, Ding Gastroenterology 2019, Zhou Comput Biol Med 2017*)

Endoscopy

ORIGINAL RESEARCH

Standalone performance of artificial intelligence for upper GI neoplasia: a meta-analysis

Julia Arribas,[1] Giulio Antonelli,[2,3] Leonardo Frazzoni,[4] Lorenzo Fuccio,[4] Alanna Ebigbo,[5] Fons van der Sommen,[6] Noha Ghatwary,[7] Christoph Palm,[8,9] Miguel Coimbra,[10] Francesco Renna,[11] J J G H M Bergman,[12] Prateek Sharma,[13] Helmut Messmann,[5] Cesare Hassan,[2] Mario J Dinis-Ribeiro[1]

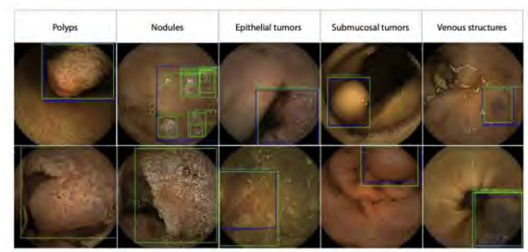


Figure 2. Representative images of protruding lesions correctly detected by the convolutional neural network (CNN) in the validation set (*blue box*, true lesion; *green box*, region identified as a protruding lesion by the CNN; number, the probability score determined by the CNN). The *blue* rectangular bounding boxes show the annotation of protruding regions as determined by experts. The *green* rectangular bounding boxes were applied by the CNN, with the name of lesion subcategory and its probability score.

Saito et al. GIE. 7/2020; 92(1):144-151

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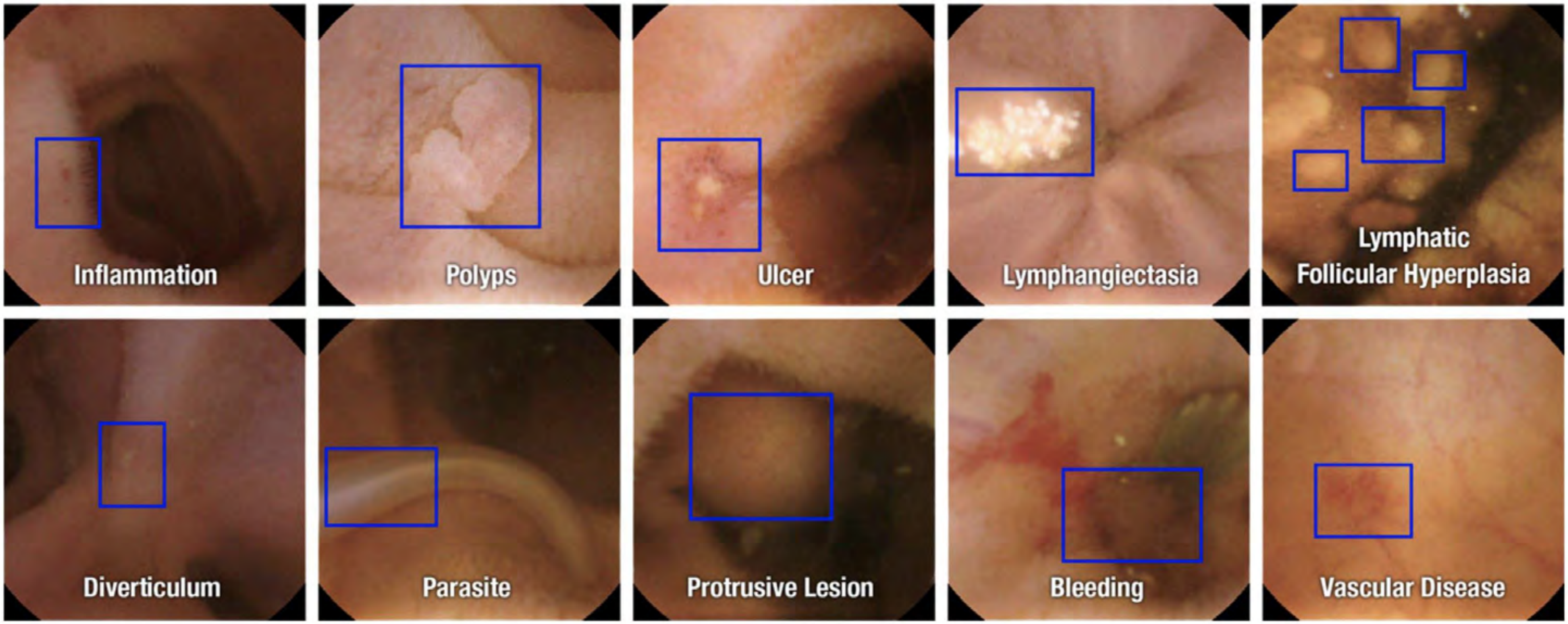
Other Applications of CADe/CADx

Other Applications of CADe/CADx



Saito et al. GIE. 7/2020; 92(1):144-151

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Other Applications of CADe/CADx

- EUS: CADx for benign vs. malignant hepatic masses (*Marya GIE 2020*); AP vs. PDAC (*Marya Gut 2020*)
- IBD: Automatic segmentation of CTe images (*Stidham IBD 2020*) endoscopic RD and Mayo score (*Bossuyt et al Gut 2020; Ozawa 2019*)

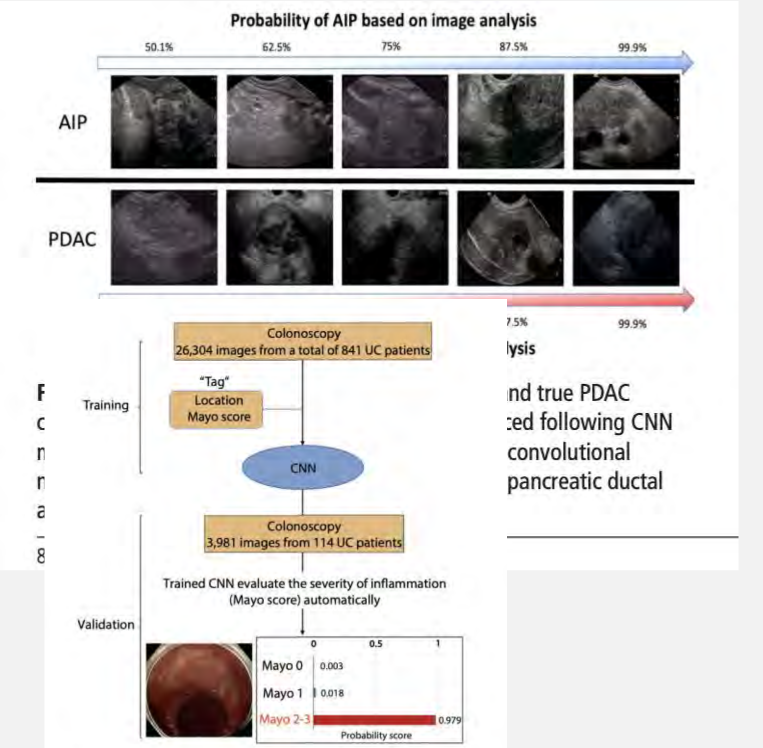


Figure 1. Study design. We used 26,304 images from 841 cumulative patients with ulcerative colitis (UC) as a training set and validated the performance of a trained convolutional neural network (CNN) in 3981 images from 114 patients with UC.

Marya et al. GIE. 5/2021; 93(5):1121-1130.e1.
Bossuyt et al. Gut. 10/2020; 69(10):1778-1786.

Other Applications of CADe/CADx

- Predictive Modeling
- Natural Language Processing (automated report generation; ChatGPT)
- And more!

Predictive Modeling

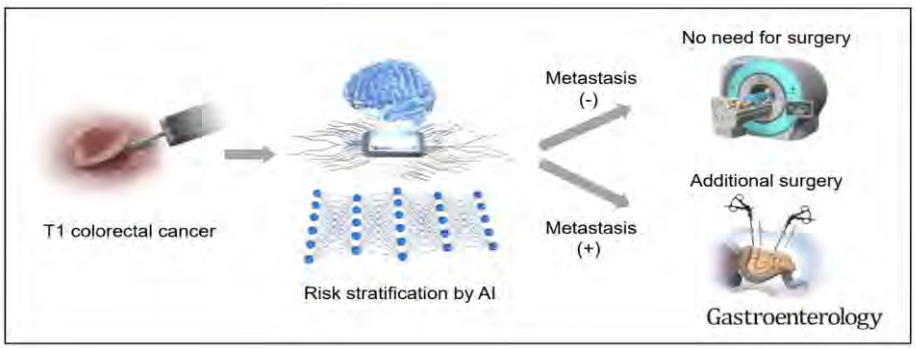
Gastroenterology 2021;160:1075–1084

Artificial Intelligence System to Determine Risk of T1 Colorectal Cancer Metastasis to Lymph Node

Shin-ei Kudo,[1,*] **Katsuro Ichimasa**,[1,*] Benjamin Villard,[2] Yuichi Mori,[1,3] Masashi Misawa,[1] Shoichi Saito,[4] Kinichi Hotta,[5] Yutaka Saito,[6] Takahisa Matsuda,[6,7] Kazutaka Yamada,[8] Toshifumi Mitani,[9] Kazuo Ohtsuka,[10] Akiko Chino,[4] Daisuke Ide,[4] Kenichiro Imai,[5] Yoshihiro Kishida,[5] Keiko Nakamura,[6,7] Yasumitsu Saiki,[8] Masafumi Tanaka,[8] Shu Hoteya,[9] Satoshi Yamashita,[9] Yusuke Kinugasa,[11] Masayoshi Fukuda,[10] Toyoki Kudo,[1] Hideyuki Miyachi,[1] Fumio Ishida,[1] Hayato Itoh,[2] Masahiro Oda,[2] and Kensaku Mori[2]

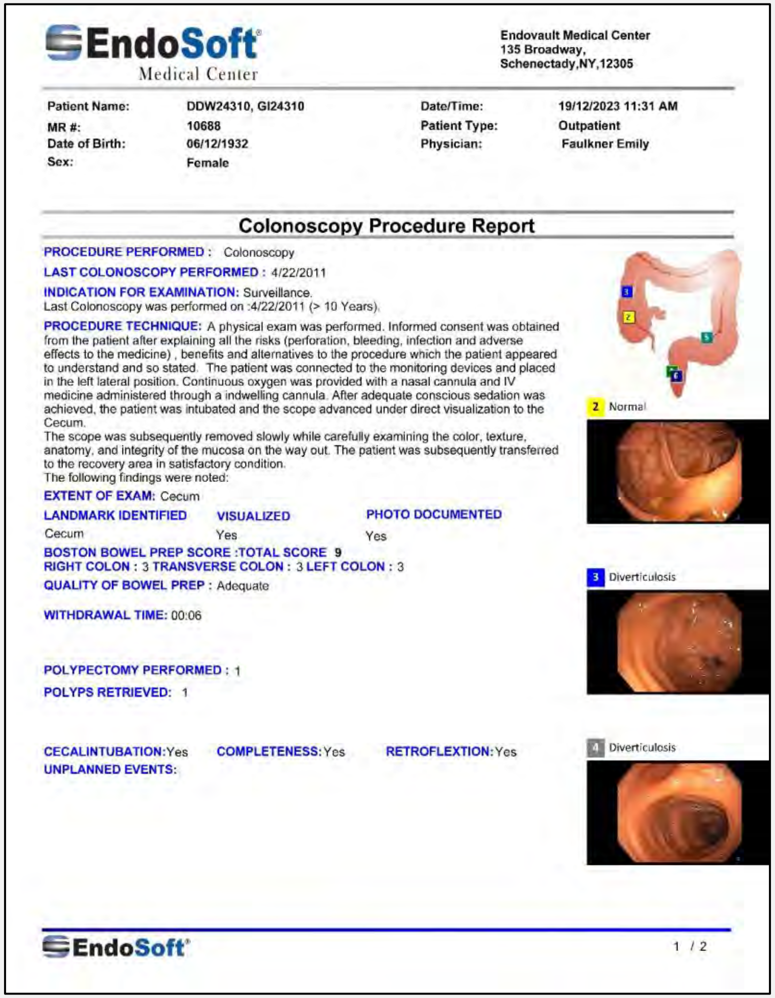
[1]Digestive Disease Center, Showa University Northern Yokohama Hospital, Yokohama, Japan; [2]Graduate School of Informatics, Nagoya University, Nagoya, Japan; [3]Clinical Effectiveness Research Group, Institute of Health and Society, University of Oslo, Oslo, Norway; [4]Department of Gastroenterology, The Cancer Institute Hospital, Japanese Foundation for Cancer Research, Tokyo, Japan; [5]Division of Endoscopy, Shizuoka Cancer Center, Shizuoka, Japan; [6]Endoscopy Division, National Cancer Center Hospital, Tokyo, Japan; [7]Cancer Screening Center, National Cancer Center Hospital, Tokyo, Japan; [8]Department of Surgery, Coloproctology Center Takano Hospital, Kumamoto, Japan; [9]Department of Gastroenterology, Toranomon Hospital, Tokyo, Japan; [10]Department of Endoscopy, Tokyo Medical and Dental University, Tokyo, Japan; and [11]Department of Gastrointestinal Surgery, Tokyo Medical and Dental University, Tokyo, Japan

CLINICAL AT



Kudo et al. Gastroenterology. 3/2021; 160(4):1075-1084.e2.

Natural Language Processing



EndoSoft Medical Center

Endovault Medical Center
135 Broadway,
Schenectady,NY,12305

Patient Name:	DDW24310, GI24310	Date/Time:	19/12/2023 11:31 AM
MR #:	10688	Patient Type:	Outpatient
Date of Birth:	06/12/1932	Physician:	Faulkner Emily
Sex:	Female		

Colonoscopy Procedure Report

PROCEDURE PERFORMED : Colonoscopy
LAST COLONOSCOPY PERFORMED : 4/22/2011
INDICATION FOR EXAMINATION: Surveillance.
Last Colonoscopy was performed on :4/22/2011 (> 10 Years).
PROCEDURE TECHNIQUE: A physical exam was performed. Informed consent was obtained from the patient after explaining all the risks (perforation, bleeding, infection and adverse effects to the medicine) , benefits and alternatives to the procedure which the patient appeared to understand and so stated. The patient was connected to the monitoring devices and placed in the left lateral position. Continuous oxygen was provided with a nasal cannula and IV medicine administered through a indwelling cannula. After adequate conscious sedation was achieved, the patient was intubated and the scope advanced under direct visualization to the Cecum.
The scope was subsequently removed slowly while carefully examining the color, texture, anatomy, and integrity of the mucosa on the way out. The patient was subsequently transferred to the recovery area in satisfactory condition.
The following findings were noted:
EXTENT OF EXAM: Cecum

LANDMARK IDENTIFIED	VISUALIZED	PHOTO DOCUMENTED
Cecum	Yes	Yes

BOSTON BOWEL PREP SCORE :TOTAL SCORE 9
RIGHT COLON : 3 TRANSVERSE COLON : 3 LEFT COLON : 3
QUALITY OF BOWEL PREP : Adequate

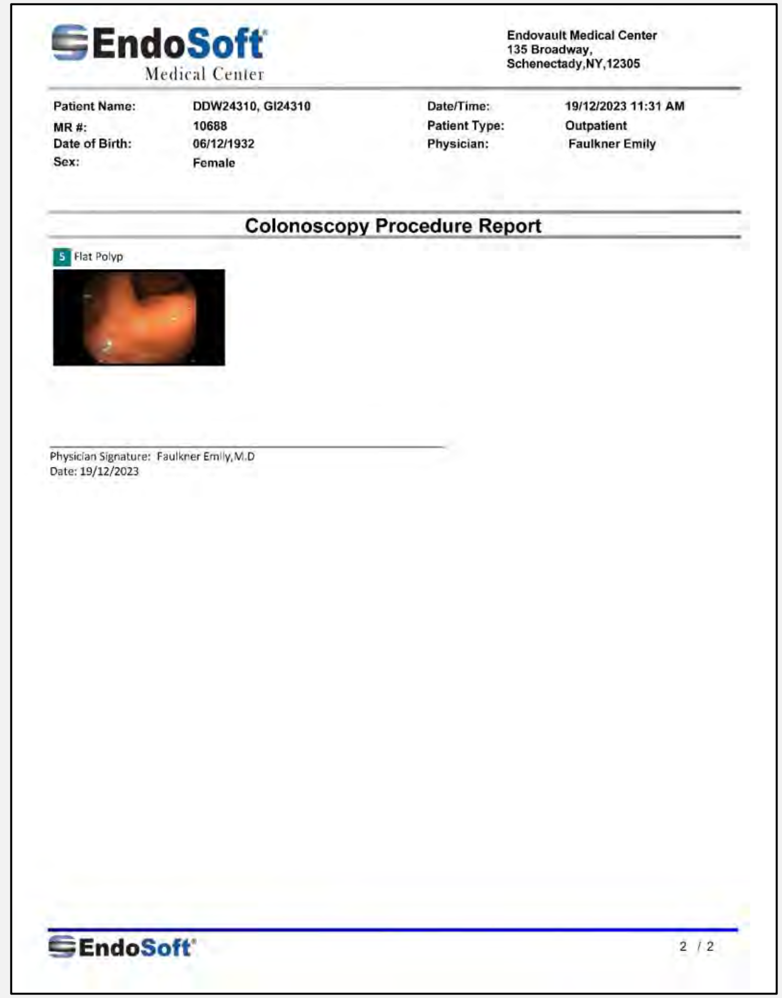
WITHDRAWAL TIME: 00:06

POLYPECTOMY PERFORMED : 1
POLYPS RETRIEVED: 1

CECALINTUBATION:Yes COMPLETENESS:Yes RETROFLEXTION:Yes
UNPLANNED EVENTS:

2 Normal
3 Diverticulosis
4 Diverticulosis

EndoSoft 1 / 2



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Date of Birth:	06/12/1932	Physician:	Faulkner Emily
Sex:	Female		

Colonoscopy Procedure Report

5 Flat Polyp

Physician Signature: Faulkner Emily,M.D
Date: 19/12/2023

EndoSoft 2 / 2

Images courtesy of Endosoft

Generative AI And Foundation Models

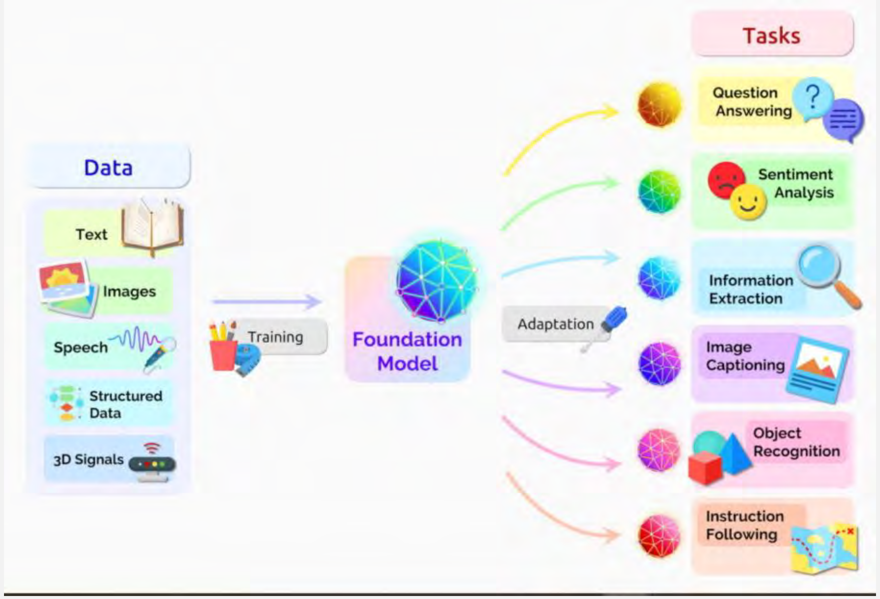
Figure. Artificial Intelligence (AI) 1.0, 2.0, and 3.0

Approximate beginning year	1950s	2011	2018-2022
	AI 1.0 Symbolic AI and probabilistic models	**AI 2.0** Deep learning	**AI 3.0** Foundation models
Core functionality and key features	Follows directly encoded rules (if-then rules or decision trees)	Predicts and/or classifies information Task-specific (1 task at a time); requires new data and retraining to perform new tasks	Generates new content (text, sound, images) Performs different types of tasks without new data or retraining; prompt creates new model behaviors
Training method	Rules based on expert knowledge are hand-encoded in traditional programming	Learning patterns based on examples labeled as ground truth	Self-supervised learning from large datasets to predict the next word or sentence in a sequence
Performance capabilities	Follows decision path encoded in its rules. *Eg, ask a series of questions to determine whether a picture is a cat or a dog.*	Classifies information based on training: *"Is this a cat or a dog?"* *"How many dogs will be in the park at noon?"*	Interprets and responds to complex questions: *"Explain the difference between a cat and a dog."*
Examples of performance	IBM's Deep Blue beat the world champion in chess **Health care:** Rule-based clinical decision support tools	Photo searching without manual tagging, voice recognition, language translation **Health care:** diabetic retinopathy detection, breast cancer and lung cancer screening, skin condition classification, predictions based on electronic health records	Writing assistants in word processors, software coding assistants, chatbots **Health care:** Med-PaLM and Med-PaLM-2, medically tuned large language models, PubMedGPT, BioGPT
Examples of challenges and risks	Human logic errors and bias in encoded rules lead to limited capability with real-world situations	Out-of-distribution problems (real-time data differs from training data) Catastrophic forgetting (not remembering early parts of a long sequence of text) Bias related to underlying training data	Hallucinations (plausible but incorrect responses based solely on predictions) Grounding and attribution Bias related to underlying training data and semantics of language in datasets

Howell et al JAMA 2024 Jan 16;331(3):242-244.

Generative AI And Foundation Models

- Foundation models:
  - Eg ChatGPT, DALL-E2
  - Neural networks (eg transformer architecture)
  - Unsupervised learning
  - Broad, flexible outputs, generative



Bommasani et al arXiv:2108.07258

Generalist Medical AI

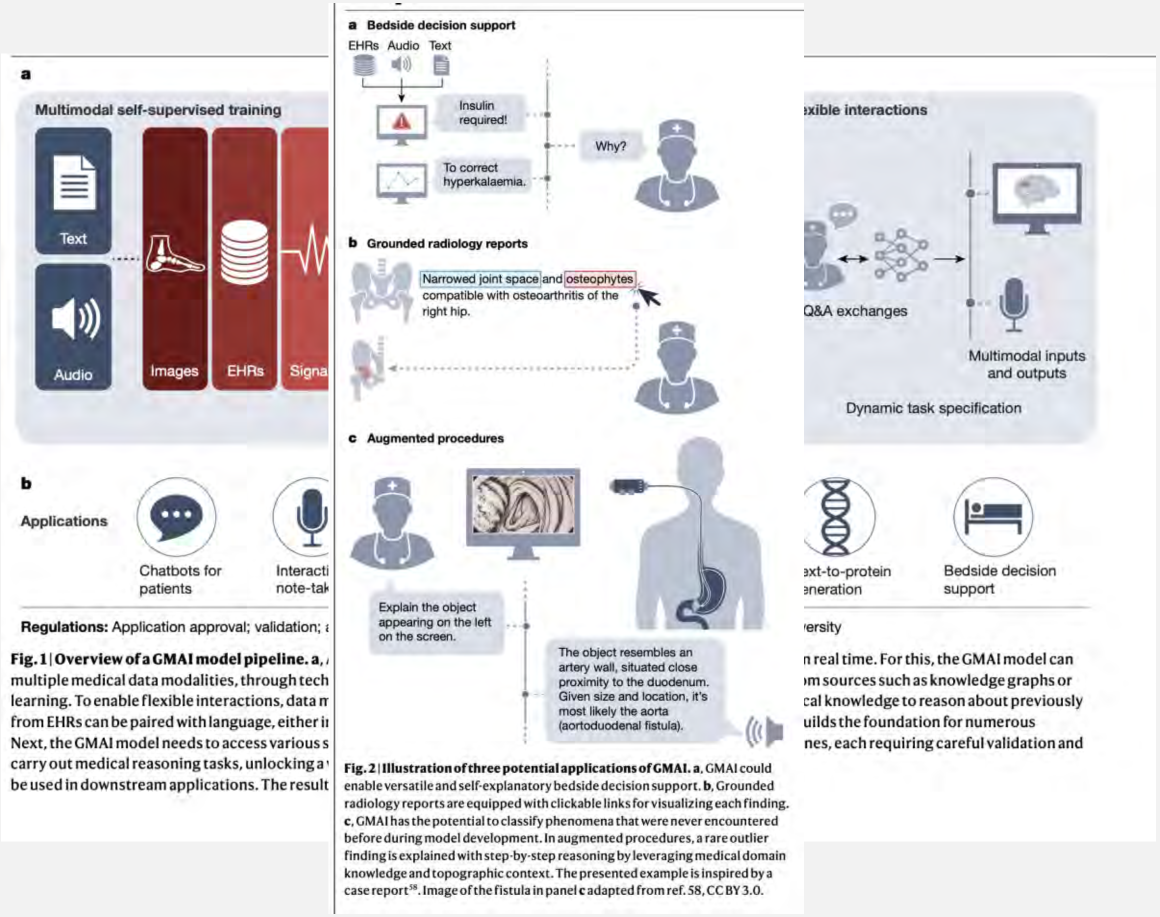


Fig. 2 | Illustration of three potential applications of GMAI. a, GMAI could enable versatile and self-explanatory bedside decision support. b, Grounded radiology reports are equipped with clickable links for visualizing each finding. c, GMAI has the potential to classify phenomena that were never encountered before during model development. In augmented procedures, a rare outlier finding is explained with step-by-step reasoning by leveraging medical domain knowledge and topographic context. The presented example is inspired by a case report[58]. Image of the fistula in panel c adapted from ref. 58, CC BY 3.0.

Moor and Rajpurkar et al. Nature 2023

CME/MOC Question:

Best Practices for CADe include all of the following except:

a. Toggling the device off during insertion and cleaning and on during a “clean” withdrawal
b. Toggling device on during intervention
c. Toggling the device off during intervention
d. Limiting bubbles and suction polyps during withdrawal

Joint Providership

ASGE
American Society for Gastrointestinal Endoscopy

CME/MOC Answer:

Best Practices for CADe include all of the following except:

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Take Home Points

- CADe is a solved problem in colonoscopy and multiple algorithms are FDA approved for clinical use
- Best practices are evolving but include careful insufflation and cleaning prior to use, toggling on during withdrawal and off during intervention
- Explosion in growth of other deep learning applications. CADe is only the beginning

Thank you!