Life as a Clinician AI Scientist and Innovator

Bringing An Idea from Bench to Bedside

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Director, AI Office, SingHealth
Senior Consultant, Surgical Retina, Singapore National Eye Center
Chief Data and Digital Officer, Singapore National Eye Center
Associate Professor, Duke NUS Medical School, Singapore
Adj Clinical Associate Professor, Byers Eye Institute, Stanford University
International Advisory Board, Lancet Digital Health

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ACADEMIC MEDICAL CENTRE

Financial Disclosure

- Co-inventor, deep learning system for retinal diseases
- Scientific advisor, EyRIS Pte Ltd, Singapore
- Consultant, Bayer
- Consultant, Carl Zeiss
- Consultant, Novartis
- Consultant, Alcon
- Consultant, AbbVie

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PATIENTS. AT THE HEART OF ALL WE DO.

Outline

- Innovation can come from anywhere, anytime and anyone
- Personal failure experiences
- A small initial success AI academic story taking a research idea from bench to bedside
- Innovation can be addictive ☺

PATIENTS. AT THE HEART OF ALL WE DO.

You don’t need to start from an Ivy league university …..

MD

PhD

2024

QS WORLD UNIVERSITY RANKINGS

307

2024

QS WORLD UNIVERSITY RANKINGS

72

You can always be a late boomer to be a scientist …..

MD
0 paper

PhD
Approx. 10 papers

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ACADEMIC MEDICAL CENTRE

You can always be a late boomer to be an innovator…..

Founded in 2018

SingHealth DUKE NUS ACADEMIC MEDICAL CENTRE

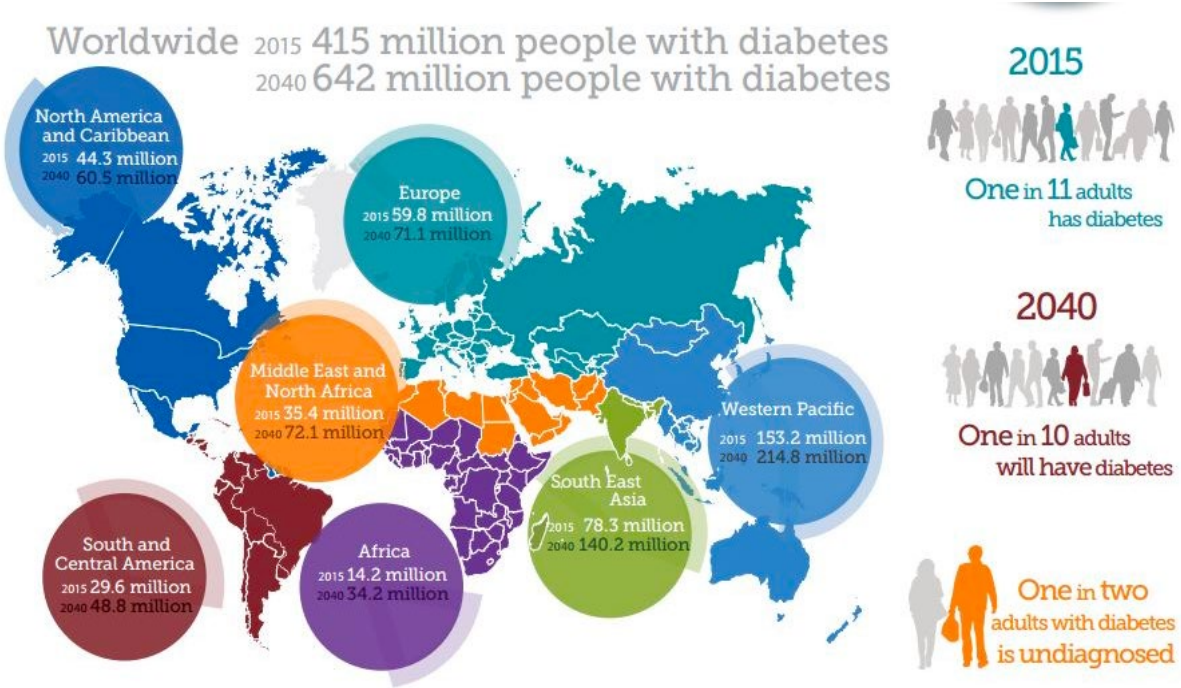
Keep your eyes on the stars,
and your feet on the ground.

Theodore Roosevelt

Solving a diabetes-related eye screening problem

PhD

THE UNIVERSITY OF WESTERN AUSTRALIA



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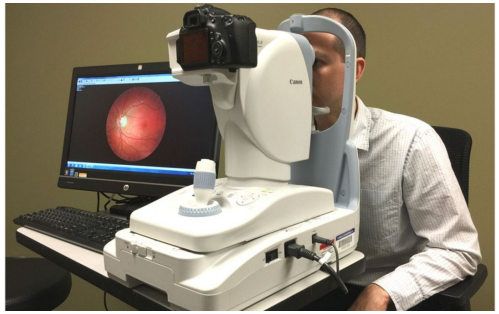
For eye screening, you need the following:

2010

Camera to take photos



Operator to take photos with patients' cooperation

Physicians to read and grade retinal photos once done

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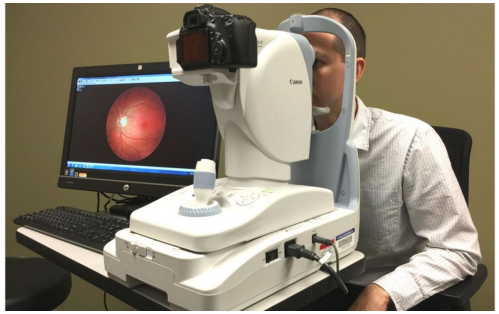
Challenges

2010

Expensive (200K USD)



- Experienced photographers
- Cooperative patients
- Eye and head movements
- Small pupil size

- Inconvenience to the physicians
- Need to read photos in the clinic

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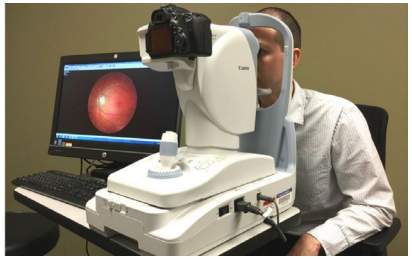
PhD proposed solutions

- Small and portable
- Cheap (40K USD)



- Only need patients' head to keep still
- Operators to take videos (5s) from left to right

- Cloud-based solution
- Portable reading device

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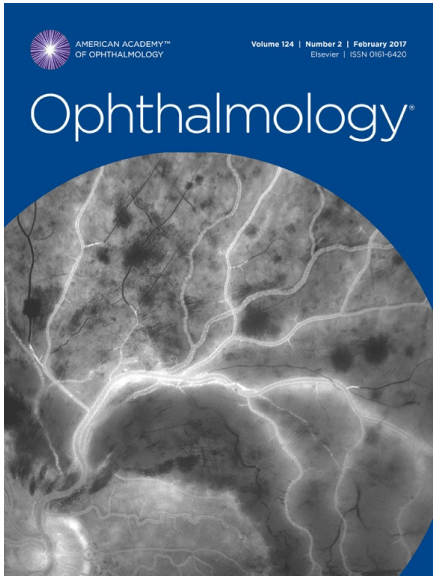
Good papers and news coverage, BUT….



REUTERS HEALTH

WIN NETWORK

- Retina videos – file size too big (1G per video for a 5s video clip)
- Requires bright flash to be turned on during the 5s (severe eye discomfort)
- No start up team that drives the business development, the team consists of a group of scientists with no start-up experience

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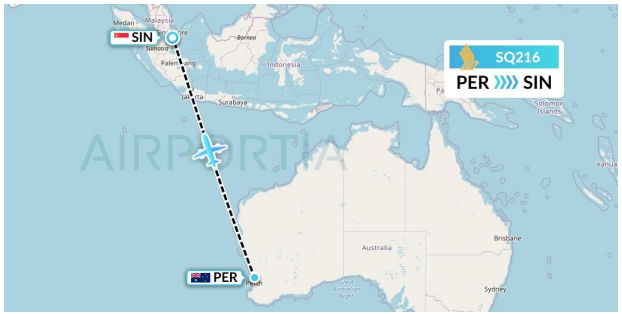
There will be always something to gain from a failed start up experience

- PhD Degree
- Basic programming (prior to deep learning era)
- Built foundation
  - To develop a new technology
  - To design a study to evaluate a new technology
  - Learnt to run robust statistical analysis
  - Write and publish papers
- Get into ophthalmology residency in Singapore (where my clinical and AI career took off)



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Meeting a great mentor could become a life changing event…..

- A clinician scientist superstar
- Spent his life long career in studying retinal imaging, and also leverage on technologies to find new biomarkers in retinal imaging for eye and systemic diseases
- Set up the retinal reading centers, national diabetic retinopathy screening program → Good data with good labels
- NOT about how many papers he previously published
- Openness to new ideas, can move extremely fast to turn ideas into papers and clinical tools
- Actively thinking of strategic ways to enable and empower you as a clinician, scientist and a leader

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Standing on the shoulder of the giant….

Singapore National Eye Centre
SingHealth

National Healthcare Group
EYE INSTITUTE
Adding years of healthy life

Established

IHiS

supports

SiDRP
SINGAPORE INTEGRATED DIABETIC RETINOPATHY PROGRAMME

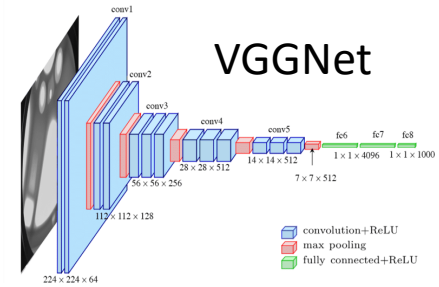
Polyclinics
SingHealth

National Healthcare Group
POLYCLINICS

National University
Polyclinics
A member of the NUHS

- In 2014 - Started the AI portfolio
- From 2010 to 2014, we have close to 200K images on DR grading performed by the graders

AlexNet



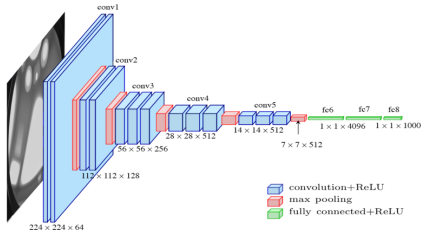
Research Question

- Can we use deep learning based AI techniques to build an AI model for diabetic retinopathy screening, using the data that we have curated in the past 5 years ?

Deep Eye Study (Initiated in 2014/2015)

- Singapore SiDRP 2010 to 2015 datasets
- Sample size: approximately 200K
- Races: Chinese, Indians and Malays
- Retina cameras: Topcon
- Reference standards: Retinal specialists

VGGNet



- Outcome: AUC, sensitivity and specificity >90%
- Prepared and submitted the paper to the Lancet in late Oct 2016

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Heard a bad news …… (Gulshan et al, JAMA 2016)

Original Investigation | Innovations in Health Care Delivery FREE

December 13, 2016

Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

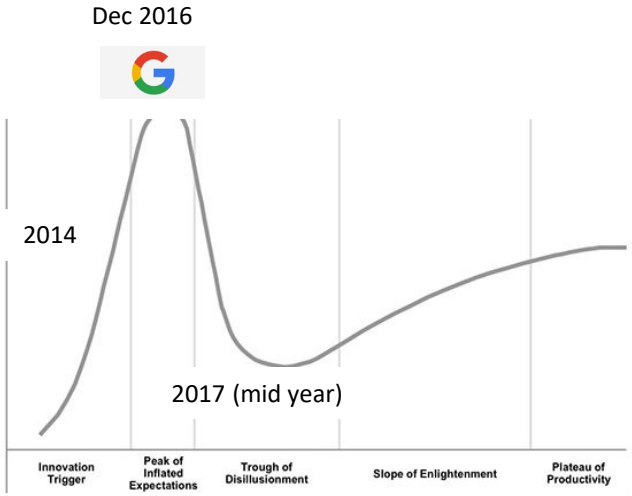
Varun Gulshan, PhD[1]; Lily Peng, MD, PhD[1]; Marc Coram, PhD[1]; Martin C. Stumpe, PhD[1]; Derek Wu, BS[1]; Arunachalam Narayanaswamy, PhD[1]; Subhashini Venugopalan, MS[1,2]; Kasumi Widner, MS[1]; Tom Madams, MEng[1]; Jorge Cuadros, OD, PhD[3,4]; Ramasamy Kim, OD, DNB[5]; Rajiv Raman, MS, DNB[6]; Philip C. Nelson, BS[1]; Jessica L. Mega, MD, MPH[7,8]; Dale R. Webster, PhD[1]

» Author Affiliations | Article Information

JAMA. 2016;316(22):2402-2410. doi:10.1001/jama.2016.17216

A Roller Coaster Ride…..

- Dec 2016 (Submission under review by Lancet)
  - 5 reviewers' comments, totalling up to 200 to 300 comments (big and small), turnover time 1 week, 3 hrs/night on average
- Rejected by Lancet, then 9 other journals
  - Nature → Nature Biotech → Nature Medicine → Science → BMJ → Lancet Diabetes and Endocrinology → Nature Communication → Diabetes Care → Annals of Internal Medicine
- From 2014 to 2017 - 0 paper and track record in AI (no paper in the field, no start up)
- 2016/2017: Applied NIG x 2 to prepare for the subsequent phase→ Rejected x 2 (reviewers did not think deep learning is something new)
- Why are you doing a computer science project when you are a clinician? Do you want to consider changing your research focus? Do you want to look into a more conventional disease specific area?



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Expanded Deep Eye Study in 2017

- More disease areas: DR + glaucoma + age-related macular degeneration
- More Countries: China, Hong Kong, USA, Mexico, Australia
- More types of studies: 1 Community-based DR screening, 5 population-based studies and 4 clinic-based DR screening
- More races: Cantonese (outside Singapore), American Black, Hispanics, Caucasians
- More retina cameras: Canon, Carl Zeiss, FundusVue
- More reference standards: Professional graders, Optometrists, Ophthalmologists

TOPCON

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We Make It Visible

Canon

JAMA | Original Investigation | INNOVATIONS IN HEALTH CARE DELIVERY

Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

Varun Gulshan, PhD; Lily Peng, MD, PhD; Marc Coram, PhD; Martin C. Stumpe, PhD; Derek Wu, BS; Arunachalam Narayanaswamy, PhD; Subhashini Venugopalan, MS; Kasumi Widner, MS; Tom Madams, MEng; Jorge Cuadros, OD, PhD; Ramasamy Kim, OD, DNB; Rajiv Raman, MS, DNB; Philip C. Nelson, BS; Jessica L. Mega, MD, MPH; Dale R. Webster, PhD

IMPORTANCE Deep learning is a family of computational methods that allow an algorithm to program itself by learning from a large set of examples that demonstrate the desired behavior, removing the need to specify rules explicitly. Application of these methods to medical imaging requires further assessment and validation.

OBJECTIVE To apply deep learning to create an algorithm for automated detection of diabetic retinopathy and diabetic macular edema in retinal fundus photographs.

DESIGN AND SETTING A specific type of neural network optimized for image classification called a deep convolutional neural network was trained using a retrospective development data set of 128 175 retinal images, which were graded 3 to 7 times for diabetic retinopathy, diabetic macular edema, and image gradability by a panel of 54 US licensed ophthalmologists and ophthalmology senior residents between May and December 2015. The resultant algorithm was validated in January and February 2016 using 2 separate data sets, both graded by at least 7 US board-certified ophthalmologists with high intragrader consistency.

EXPOSURE Deep learning–trained algorithm.

MAIN OUTCOMES AND MEASURES The sensitivity and specificity of the algorithm for detecting referable diabetic retinopathy (RDR), defined as moderate and worse diabetic retinopathy, referable diabetic macular edema, or both, were generated based on the reference standard of the majority decision of the ophthalmologist panel. The algorithm was evaluated at 2 operating points selected from the development set, one selected for high specificity and another for high sensitivity.

RESULTS The EyePACS-1 data set consisted of 9963 images from 4997 patients (mean age, 54.4 years; 62.2% women; prevalence of RDR, 683/8878 fully gradable images [7.8%]); the Messidor-2 data set had 1748 images from 874 patients (mean age, 57.6 years; 42.6% women; prevalence of RDR, 254/1745 fully gradable images [14.6%]). For detecting RDR, the algorithm had an area under the receiver operating curve of 0.991 (95% CI, 0.988-0.993) for EyePACS-1 and 0.990 (95% CI, 0.986-0.995) for Messidor-2. Using the first operating cut point with high specificity, for EyePACS-1, the sensitivity was 90.3% (95% CI, 87.5%-92.7%) and the specificity was 98.1% (95% CI, 97.8%-98.5%). For Messidor-2, the sensitivity was 87.0% (95% CI, 81.1%-91.0%) and the specificity was 98.5% (95% CI, 97.7%-99.1%). Using a second operating point with high sensitivity in the development set, for EyePACS-1 the sensitivity was 97.5% and specificity was 93.4% and for Messidor-2 the sensitivity was 96.1% and specificity was 93.9%.

CONCLUSIONS AND RELEVANCE In this evaluation of retinal fundus photographs from adults with diabetes, an algorithm based on deep machine learning had high sensitivity and specificity for detecting referable diabetic retinopathy. Further research is necessary to determine the feasibility of applying this algorithm in the clinical setting and to determine whether use of the algorithm could lead to improved care and outcomes compared with current ophthalmologic assessment.

JAMA. doi:10.1001/jama.2016.17216
Published online November 29, 2016.

Editorial
Supplemental content

Author Affiliations: Google Inc, Mountain View, California (Gulshan, Peng, Coram, Stumpe, Wu, Narayanaswamy, Venugopalan, Widner, Madams, Nelson, Webster); Department of Computer Science, University of Texas, Austin (Venugopalan); EyePACS LLC, San Jose, California (Cuadros); School of Optometry, Vision Science Graduate Group, University of California, Berkeley (Cuadros); Aravind Medical Research Foundation, Aravind Eye Care System, Madurai, India (Kim); Shri Bhagwan Mahavir Vitreoretinal Services, Sankara Nethralaya, Chennai, Tamil Nadu, India (Raman); Verily Life Sciences, Mountain View, California (Mega); Cardiovascular Division, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts (Mega).
Corresponding Author: Lily Peng, MD, PhD, Google Research, 1600 Amphitheatre Way, Mountain View, CA 94043 (lhpeng@google.com).

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Filed technical disclosure + paper is published → EyRIS

IHiS
because IT's in healthcare

procures and manages all external vendors for SIDRP i.e. vendor and software maintenance for OphthLive system by
(i) Topcon
(ii) Pellucid

Singapore National Eye Centre
SingHealth

National Healthcare Group EYE INSTITUTE
Adding years of healthy life

Established

supports

SiDRP
SINGAPORE INTEGRATED DIABETIC RETINOPATHY PROGRAMME

Polyclinics
SingHealth

National Healthcare Group POLYCLINICS

National University Polyclinics
A member of the NUHS

SINGAPORE EYE RESEARCH INSTITUTE

NUS National University of Singapore

Co-developed

Integrating AI into the real-world settings

SELENA+

JAMA | Original Investigation | INNOVATIONS IN HEALTH CARE DELIVERY

Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

EyRIS

2018

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Co-inventors Challenges

- All academics with full time universities and healthcare senior leadership appointments (except for me)
- Just completed my residency and about to start surgical retina fellowship, invested 15 years (10 years MD PhD + 5 years eye residency) → to run a start up (as an amateur without any prior business and start up experience), or to run a new start up as a CEO or CMO
- Co-inventor team spent at least 6 to 12 months to look for a CEO to form the new spin-off → Mr Teik Kin Lai (CEO NovaHealth, KLSE listed Co → CEO EyRIS Pte Ltd)

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EyRIS Challenges

2018

2022

No hardware capabilities

POLICY, ARTIFICIAL INTELLIGENCE, HEALTH TECH

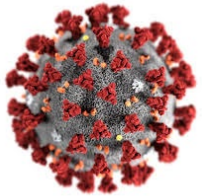
Medicare prices AI-based screening for diabetic retinopathy

The agency set a national payment amount for AI-based screenings for diabetic retinopathy in its 2022 Medicare Physician Fee Schedule final rule. It would also allow the screenings to count toward quality measures.

By ELISE REUTER

92229***

COVID-19



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COVID-19 – is both a crisis and an opportunity for EyRIS ….

- Intermittent lock-down period (2019 - 2021)
- Less time to travel, more time to meet collaborators
- People realize the importance of tele-health, and AI diagnostic tools
- More time to apply for the regulatory approvals from different countries, and also sharpening business models
  - Combined with a portable retinal camera
  - To partner with the other retinal imaging-based AI algorithms in exploring a mutually agreed go-to-market strategy

nature medicine

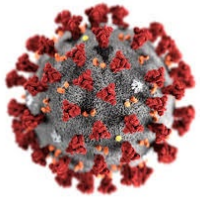
Comment | Published: 27 March 2020

Digital technology and COVID-19

Daniel Shu Wei Ting, Lawrence Carin, Victor Dzau & Tien Y. Wong

Nature Medicine **26**, 459–461 (2020) | Cite this article

130k Accesses | **896** Citations | **211** Altmetric | Metrics



CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

Genomics and Precision Health

Using Digital Technologies in Precision Public Health: COVID-19 and Beyond

Posted on April 6, 2020 by Muin J. Khoury, Scott Bowen, Office of Genomics and Precision Public Health, Centers for Disease Control and Prevention, Atlanta, Georgia; Paula Braun, Entrepreneur in Residence, Centers for Disease Control and Prevention

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If the AI algorithm is robust, and business models are appropriate……..
EyRIS 6 years later….

Market reach

500,000
Patients Screened since launch

300
Locations

5
countries

3
National screening programs

90%
Cost reduction
vs manual screening

5x
Improvement
in screening capacity

Time taken to
generate a
report

Singapore National Eye Centre
SingHealth

SINGAPORE EYE RESEARCH INSTITUTE

Next 3 to 5 years road map – more countries and disease areas

NATIONAL SCREENING PROGRAMS

- Singapore
- Oman
- Brunei
- United Arab Emirates

OPTOMETRISTS, CLINICS & HOSPITALS

DISTRIBUTORS

CAMERA MANUFACTURERS

OTHERS

Insurers

NGOs

PUBLIC / PRIVATE PAYER COVERAGE IN SEVERAL GEOGRAPHIES

Singapore, **Oman**, **Brunei**, **UAE**

- Part of National Health Screening Program
- **Fully reimbursable for diabetic population screening**
- Discussions with UAE at near final stage

South Africa

- Tie up with Discovery – One of **the largest private insurance providers in South Africa**

Australia

- $60 coverage for eye screening
- Tie up with 'Chemist warehouse' – **private pharmacy network responsible for 60% of all prescription in Australia**

United States

- Existing reimbursement code to covers **upto $55 for use of AI for eye check-up**

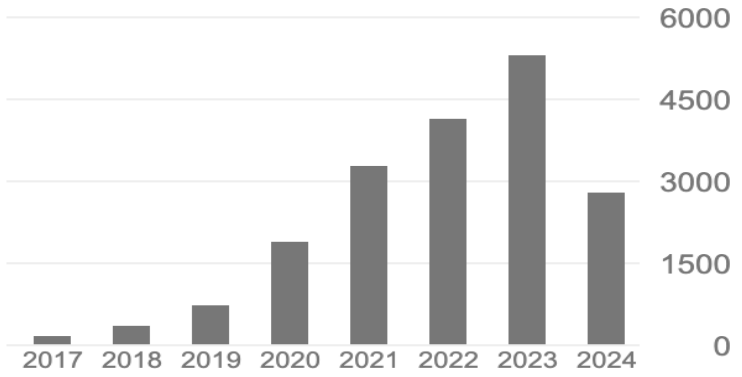
If you believe in what you do, train and work hard….

	MD PhD	Eye and AI Specialization	Faculty
Right foundation		FULBRIGHT	
Right place			
Right time	2024 QS Ranking: 307	World's best hospital: 4th	World's best eye hospital: 2nd
Right mentor			2024 QS Ranking: 8th
Right team			
	2024 QS Ranking: 72	World's best eye hospital: 1st	2024 QS Ranking: 5

You'll get there one day …..

Google Scholar May 22nd, 2024

	All	Since 2019
Citations	19121	18344
h-index	59	57
i10-index	162	159



- >250 publications
- 45 were published in high impact journals such as JAMA, NEJM, Lancet, Nature Medicine, Nature Biomedical Engineering, Lancet Digital Health and etc
- Research areas
  - Machine learning, deep learning, generative AI (large language models)
  - Explainable AI, privacy preserving technologies, ethics, blockchain
- International and AI Steering Committee
  - Equator Network - STARD-AI, QUADAS-AI and DECIDE-AI
  - MOH AI Steering Committee
- International Advisory Board – Lancet Digital Health
- AI Innovation Mentor – Stanford University

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You'll be recognized one day…..

Top 100 World's Power list in Ophthalmology (2022, 2023 and 2024)

expertscape
Your first step to a Second Opinion

Expertise in Deep Learning: Worldwide

ExpertScape (2012-2023) ranked from worldwide from >100K researchers

- Deep Learning – 3rd (used to be 1st in 2021)
- Artificial Intelligence – 8th
- Machine Learning – 11th
- Blockchain – 35th

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It will never be an ending innovation interest and opportunities….

AI for Retina and Systemic Screening

EyRIS

AI-enabled for Myopia Care

Ai-Sight

Gen AI-enabled digital health wallet for smart remote care

BeGood

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Good news for EyRIS – Recent 10M USD expression of interest

Announcement details

OTHERS Nova MSC Berhad (NOVAMSC or Company) Term Sheets With Jostar Investment VCC

NOVA MSC BERHAD

Type	Announcement
Subject	OTHERS
Description	Nova MSC Berhad (NOVAMSC or Company) Term Sheets With Jostar Investment VCC

TS2 records Jostar's desire to invest into EyRIS with an investment amount of USD5.0 million (approximately RM23.9 million) in a single or multiple tranches subject to the finalised valuation of EyRIS as of the closure date of the accounting due diligence, and negotiation between the parties.

OTHERS Nova MSC Berhad (NOVAMSC or Company) Term Sheets With Mark Investment Group VCC

NOVA MSC BERHAD

Type	Announcement
Subject	OTHERS
Description	Nova MSC Berhad (NOVAMSC or Company) Term Sheets With Mark Investment Group VCC

TS2 records MIG's desire to invest into EyRIS with an investment amount of USD5.0 million (approximately RM23.6 million) in a single or multiple tranches subject to the finalised valuation of EyRIS as of the closure date of the accounting due diligence, and negotiation between the parties.

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AIDOC – Radiological AI Imaging

Series D, led by TCV - Raised 110M USD in both Series A and B

ORGANIZATION

Aidoc

Summary | Financials | People | Technology

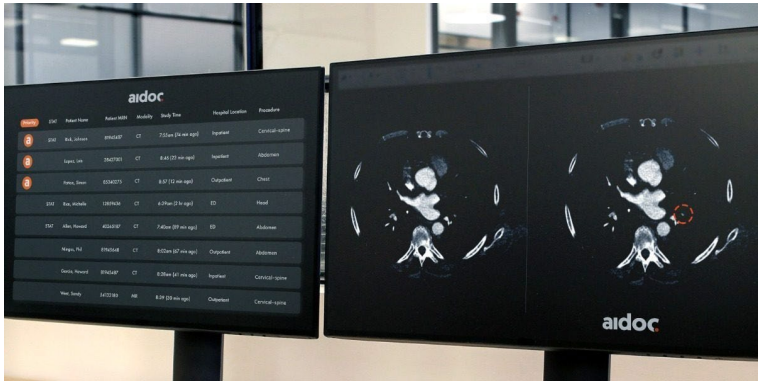
About

Aidoc specializes in developing artificial intelligence tools for radiologists and multidisciplinary response teams.

- Tel Aviv, Tel Aviv, Israel
- 251-500
- Venture - Series Unknown
- Private
- aidoc.com

Highlights

- Total Funding Amount — Unlock for free
- Contacts 165
- Employee Profiles 7
- Investors 12
- Similar Companies 11



News • Jun 16, 2022

MobiHealthNews – Aidoc raises $110M to expand AI-enabled imaging platform

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Gen AI in Health Opportunities – Abridge (Clinical Documentation)

Series B, led by Spark Capital, Raised 30M USD at 200 M valuation

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Lifepoint Health | Mayo Clinic | UC Investments | SCAN Group | The American College of Cardiology

(Graphic: Business Wire)

abridge

October 26, 2023 08:00 AM Eastern Daylight Time

PITTSBURGH--(BUSINESS WIRE)--Abridge, the leader in generative AI for clinical documentation, announced a Series B raise of $30 million, led by Spark Capital. The round also included existing investor Bessemer Venture Partners, as well as several leading healthcare innovators including CVS Health Ventures, Kaiser Permanente Ventures, Lifepoint Health, Mayo Clinic, SCAN Group, UC Investments (University of California), and the American College of Cardiology. This investment will support large-scale health system rollouts and accelerate product advances that will create additional value for patients, clinicians, and health systems.

Shiv Rao, cofounder and CEO, Abridge. ABRIDGE

The Series B round led by Spark Capital values 5-year old Abridge, which is used by 5,000 doctors, at $200 million. But it's up against Nuance, which Microsoft bought for $18.8 billion and is used by half a million doctors.

Mayo Clinic, CVS Health Ventures, Kaiser Permanente Ventures

Singapore National Eye Centre
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SINGAPORE EYE RESEARCH INSTITUTE

Gen AI in Health Opportunities – Ambience Healthcare

Series B, led by OpenAI, Kleiner Perkins - Raised 100M USD in both Series A and B Andreessen Horowitz and Optum Ventures

Ambience Healthcare raises $70M for its AI assistant led by OpenAI and Kleiner Perkins

Ingrid Lunden @ingridlunden / 6:05 PM GMT+8 • February 6, 2024 Comment

Ambience does not disclose how many customers it has, nor how much data its platform has been used to process. But customers it discloses include UCSF, Memorial Hermann Health System, John Muir Health, The Oncology Institute, GI Alliance, Midi Health and Eventus WholeHealth, and the investors in this round also speak to the traction it has seen so far.

Kleiner Perkins and OpenAI's Startup Fund are co-leading this Series B, with Andreessen Horowitz and Optum Ventures (two of its very long list of big-name previous backers) also participating. The investment has a strategic element to it, as Kleiner Perkins and OpenAI have been co-investing in other vertically-focused AI startups, such as this $80 million round in legal AI specialist Harvey.AI this past December. This round brings the total raised by the company to $100 million. It's not disclosing valuation, but for a little context, PitchBook estimated it at $126 million post-money when it raised its Series A in 2022.

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World Class AI Health Innovation Hub

The Next Silicon Valleys: Singapore as a Gateway to Southeast Asia

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Source : Singapore Economic Development Board

Singapore is known among some as "Silicon Valley of Asia" as it's developed into a leading startup hub in the region with an ecosystem valued at $21B.

The Singapore Fintech Festival is one of the world's biggest annual fintech gatherings.

Digital health is also hot in Singapore, with $4B in government funding for health and biomedical sciences R&D, and many great digital health startups are flourishing.

The city has a reputation for ease of doing business owing to startup grants and the efficient tax regime. Singapore is situated as an intersection for different talents and backgrounds.

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Thank you !

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