Evaluation of Outbreak Prediction, Detection and Annotation

Focus Group AI for Health – Topic Group Outbreaks
ITU-D Emerging Tech Week – 9 July 2021

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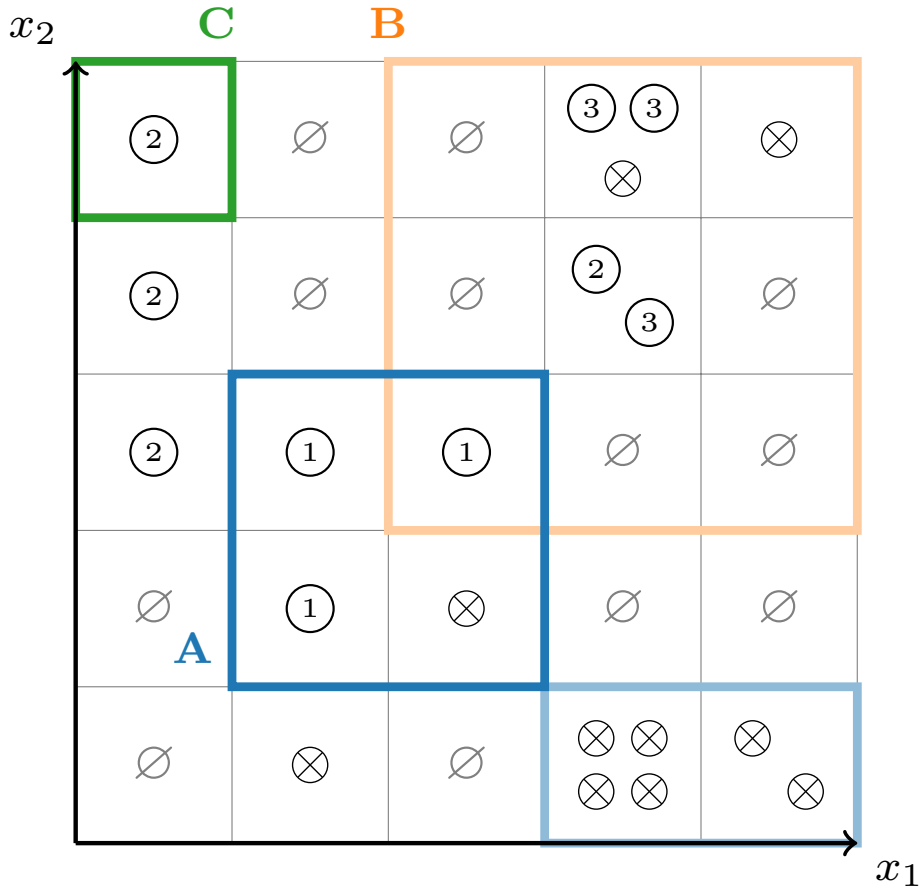
Setting

Process

- reported (infectious disease) cases
- epidemic/outbreak vs. endemic
- “outbreak” = “epidemiologicaly linked”
- “endemic” = “background noise”

Tasks

- prediction = cases not yet observed
- detection = cases observed up to now
- annotation = cases in the past



Data (case) labels = outbreak IDs = 1, 2, 3, ⊗, ∅
Signal labels: **A**, **B**, **C**, ⊗, ∅

Probabilities

Inputs

- data cell $\boldsymbol{x}$ = coordinates in smallest relevant resolution
- data label, classes d_i = outbreak labels
- signal label, classes s_j

Outputs

- $\mathrm{p}(d_i|\boldsymbol{x})$: probability of outbreak d_i in cell $\boldsymbol{x}$, from the data
- $\hat{\mathrm{p}}(d_i|\boldsymbol{x})$: probability of outbreak d_i in cell $\boldsymbol{x}$, from the algorithm

Data

- $\mathrm{p}(d_i|\boldsymbol{x}) = n(d_i, \boldsymbol{x}) / \sum_l n(d_l, \boldsymbol{x})$

Algorithm

- $\hat{\mathrm{p}}(d_i|\boldsymbol{x}) = \sum_j \hat{\mathrm{p}}(d_i|s_j, \boldsymbol{x})\, \hat{\mathrm{p}}(s_j|\boldsymbol{x})$
- $\hat{\mathrm{p}}(s_j|\boldsymbol{x}) = w(s_j, \boldsymbol{x}) / \sum_m w(s_m, \boldsymbol{x})$, with w the algo output
- $\hat{\mathrm{p}}(d_i|s_j, \boldsymbol{x}) =$ information on outbreaks, depends on the algo

Scores (standard)

Regression

- of $\hat{\mathrm{p}}$ against p, e.g., RMSE $= \sqrt{\sum(\hat{\mathrm{p}} - \mathrm{p})^2/N}$

Mutual information

- between outbreaks and signals: $I = \sum_{d,s} \mathrm{p}(d,s) \log(\mathrm{p}(d,s)/\mathrm{p}(d)\hat{\mathrm{p}}(s))$

Classification (confusion matrix)

- class based
- 2 thresholds: on $\hat{\mathrm{p}}$ and p
  $\Longrightarrow$ TP, FP, TN, FN
  $\Longrightarrow$ sensitivity, specificity, precision, F1, ...

Scores (epidemiology)

Weight individual cell

- e.g., according to number of outbreak cases

Space-time distance

- decreasing as function of distance
- e.g., timeliness (0 if signal is too early, reference = first case in a given outbreak)

Toy example

on previous grid, 4 simple scenarios and algo akin to anomaly detection, small thresholds:

- specific: no signal, three classes
- sensitive: one overall certain signal, three classes
- perfect 3: three signals, three classes, $w \equiv \mathrm{p}$
- perfect 1: one signal, one class, $w \equiv \mathrm{p}$
- random: one signal with random w's, one class

scenario	F1	F1 *
specific	0.31	0.57
sensitive	0.13	0.10
perfect 3	0.70	0.83
perfect 1	1	1
random	0.56	0.67

* weighted by # class cases

Outlook

- fairness (maximin) + ethics
- simulations and implementation of standard algorithms
- software package
- real-world application

Thank you!

FG-AI4H: www.itu.int/en/ITU-T/focusgroups/ai4h

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AI for Natural Disaster Management

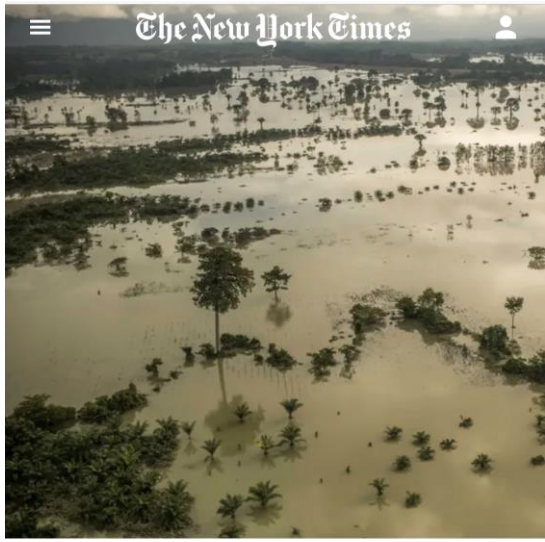
ITU Focus Group

Monique Kuglitsch
Fraunhofer HHI

The challenge

Natural disasters are damaging physical events caused by natural hazards.

The situation is exacerbated in **certain regions** and for certain **populations;** and is expected to **worsen**.



A view of the vast flooding in Guatemala after Hurricanes Eta and Iota struck one after the other last month.

2 Hurricanes Devastated Central America. Will the Ruin Spur a Migration Wave?

(4 Dec 2020, NYT)

The challenge

Natural disasters feature prominently in the activities of multiple **UN organizations** and **programmes** including

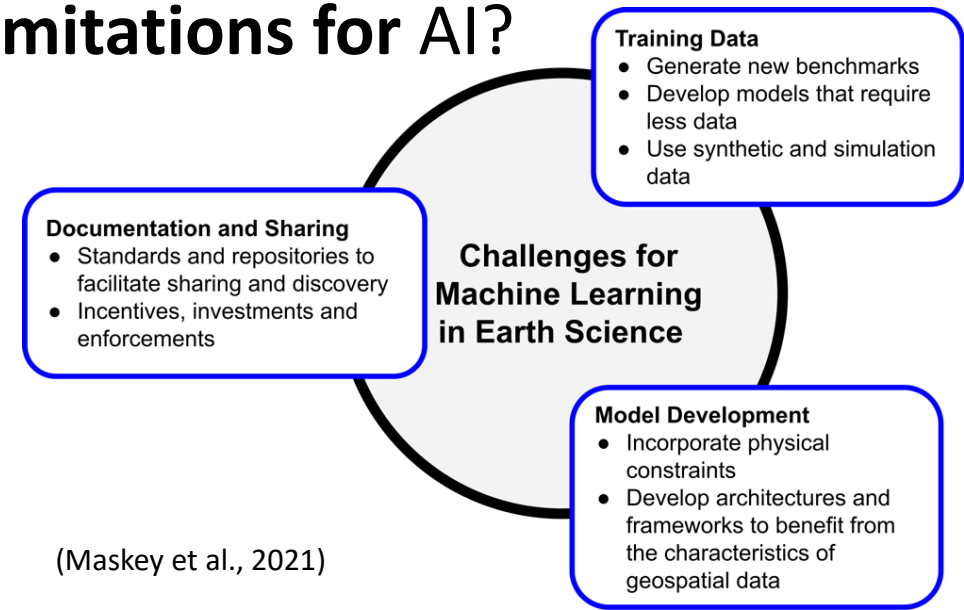
- SDGs
- policy-guiding publications (e.g., Sendai Framework, IPCC SREX)

iStock-964362096

The questions

Through tapping the **potential of AI**, can we improve our **understanding** of natural hazards, our ability to **detect** events in real-time, our ability to **forecast** events, and our ability to effectively **communicate** an impending or ongoing disaster?

What are the **best practices** and **limitations for** AI?



(Maskey et al., 2021)

The goals

Explore best practices in:

- **data** collection, monitoring, and handling for training and testing of AI-based algorithms;
- **AI-based algorithms** for reconstructing, detecting, and forecasting events; and
- effective **communication**.

Data

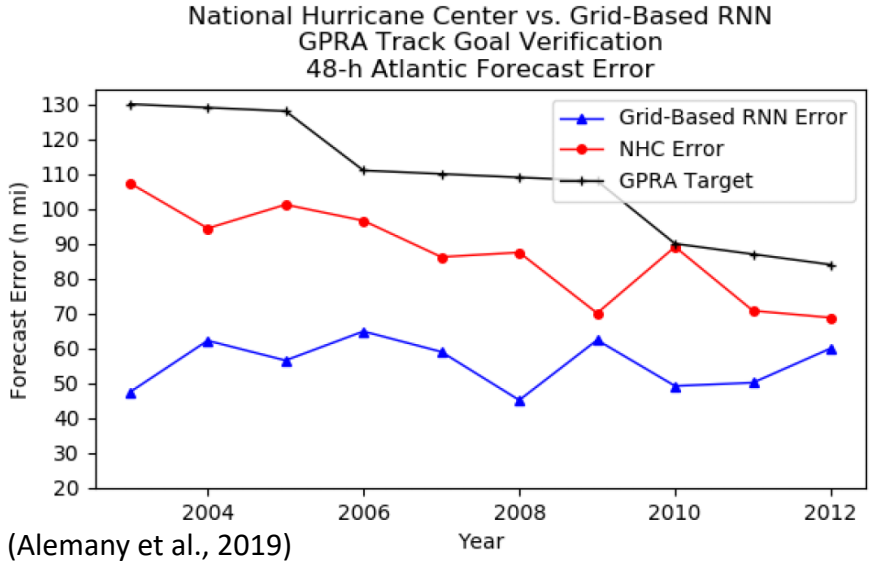
Some questions to explore are:

- what **requirements** should data meet when being used to train or test an AI-based algorithm?
- can AI-based algorithms be used to **enhance** data quantity and quality?

AI-based algorithms

Some questions to explore are:

- what is the current **gold standard** method to reconstruct, detect, or forecast events? How can AI-based algorithms bring these methods to the **next level**?
- what should be considered when **training** and **evaluating** an AI-based algorithm?



(Alemany et al., 2019)

Communication

Some questions to explore are:

- once an event has been forecast or triggered, how can AI assist with the immediate response?
- how do we ensure that communication methods are reliable and trusted by the population? Are they accompanied by a clear set of protocols to ensure that individuals know how to respond?

Key deliverables

- **Workshops**
- **Roadmap**
- **Glossary**
- Three non-normative **technical reports**
- **Educational materials**

FG-AI4NDM

What is an **ITU Focus Group**?

- Supports the efforts of an associated **ITU Study Group**. Study Group 2 mandate includes *"telecommunications for disaster relief/early warning, network resilience, and recovery."*
- Provides a working environment for **pre-standardization or standardization** activities in a chosen area.
- Can be rapidly established and has freedom to choose working methods, leadership, financing, and desired outputs ("deliverables").

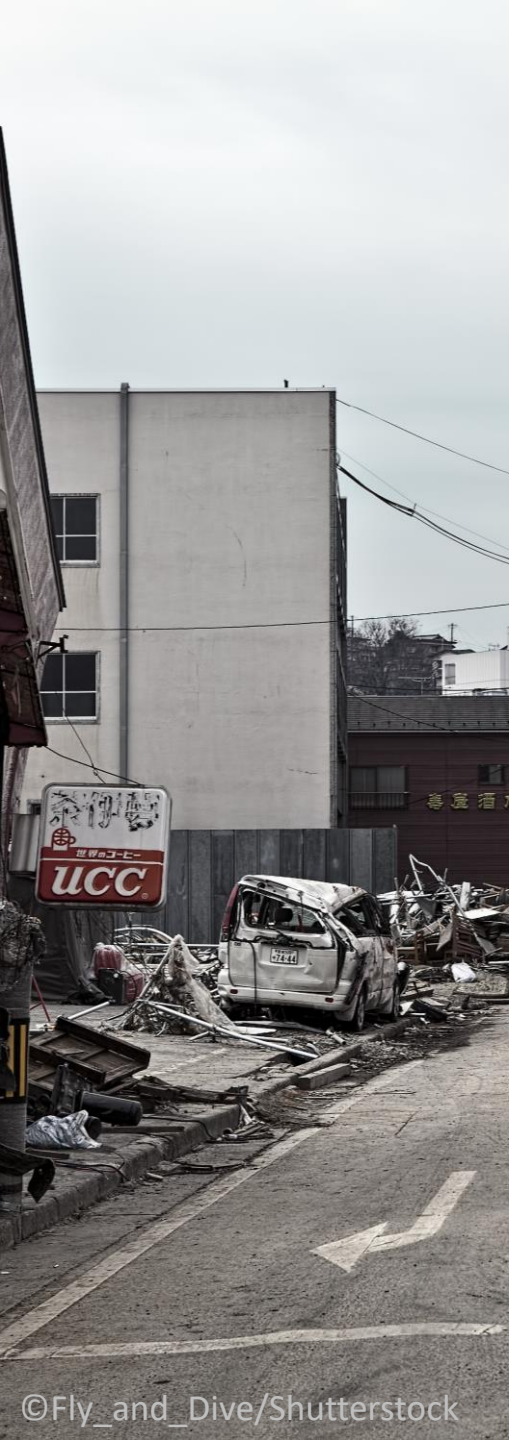
FG-AI4NDM

ITU/WMO/UNEP Focus Group on AI for Natural Disaster Management (**FG-AI4NDM**) converges the ICT expertise of ITU with natural disaster expertise from the WMO and UNEP.

Creates an atmosphere that is conducive to international, multi-stakeholder, and interdisciplinary collaboration.

ITU

UN environment programme



FG-AI4NDM

Management Team

ITU TSB
Mythili Menon, Advisor &
Hiba Tahawi, Secretariat

WG-Data | WG-Modelling | WG-Comms | WG-Roadmap — Technical reports

TG-AI for flood monitoring and detection

TG-AI for landslide monitoring and detection

TG-AI for tsunami geodetic enhancements to tsunami monitoring and detection

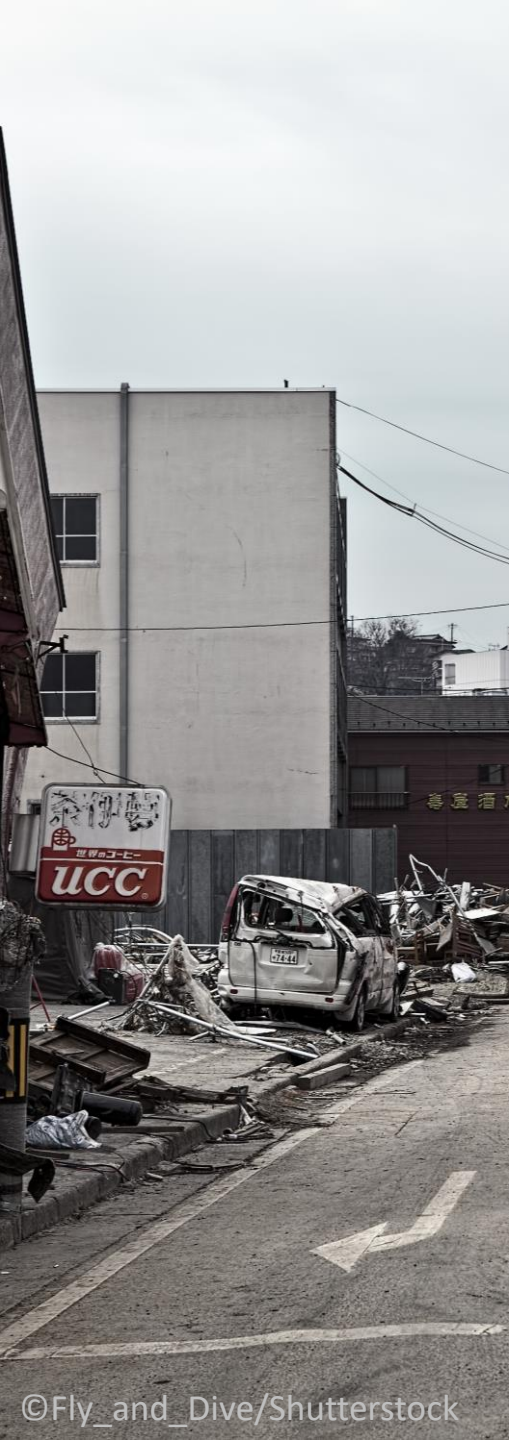
TG-AI for snow avalanche monitoring and detection

TG-AI for volcanic eruption forecasting

TG-AI for wildfire monitoring and detection

TG-AI for multihazard communication technologies

Use cases



FG-AI4NDM

Management Team

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Monique Kuglitsch
Fraunhofer HHI, Germany

Vice Chair
Elena Xoplaki
University of Giessen, Germany

Vice Chair
Juerg Luterbacher
WMO

Vice Chair
Muralee Thummarukudy
UNEP

Vice Chair
Srinivas Chaganti
DOT, India

Vice Chair
Rakiya Babamaji
NASRDA, AU-DRR Af-STAG, & UNDRR-GRAF, Nigeria

Vice Chair
Yan Chuan Wang
China Telecom, China

Get involved!

Visit our website (https://itu.int/go/fgai4ndm)

Peruse our **onboarding document** for guidance on how to:

- Create a free **ITU user account**
- Join our low-volume **mailing list**
- **Register** for our workshops/meetings
- Use our remote participation platform (**MyMeetings**)
- Access our **collaboration site**
- Submit written **contributions**

Thank you!

Naomi Lee
Co-Chair of ITU/WHO FG-AI4H
The Lancet
UK

AI for Health

ITU-WHO Focus Group

itu.int/go/fgai4h

World Health Organization

Funding support by:
fondation BOTNAR

What to do when supply < demand?

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ITU-WHO Focus Group

- WHO has made **universal health coverage** a top priority
- **SDG3** is “Good Health and Well-being”
- WHO Constitution declares “highest attainable standard of health” a **human right**
- UN member states have pledged to “**leave no one behind**”

What to do when supply < demand?

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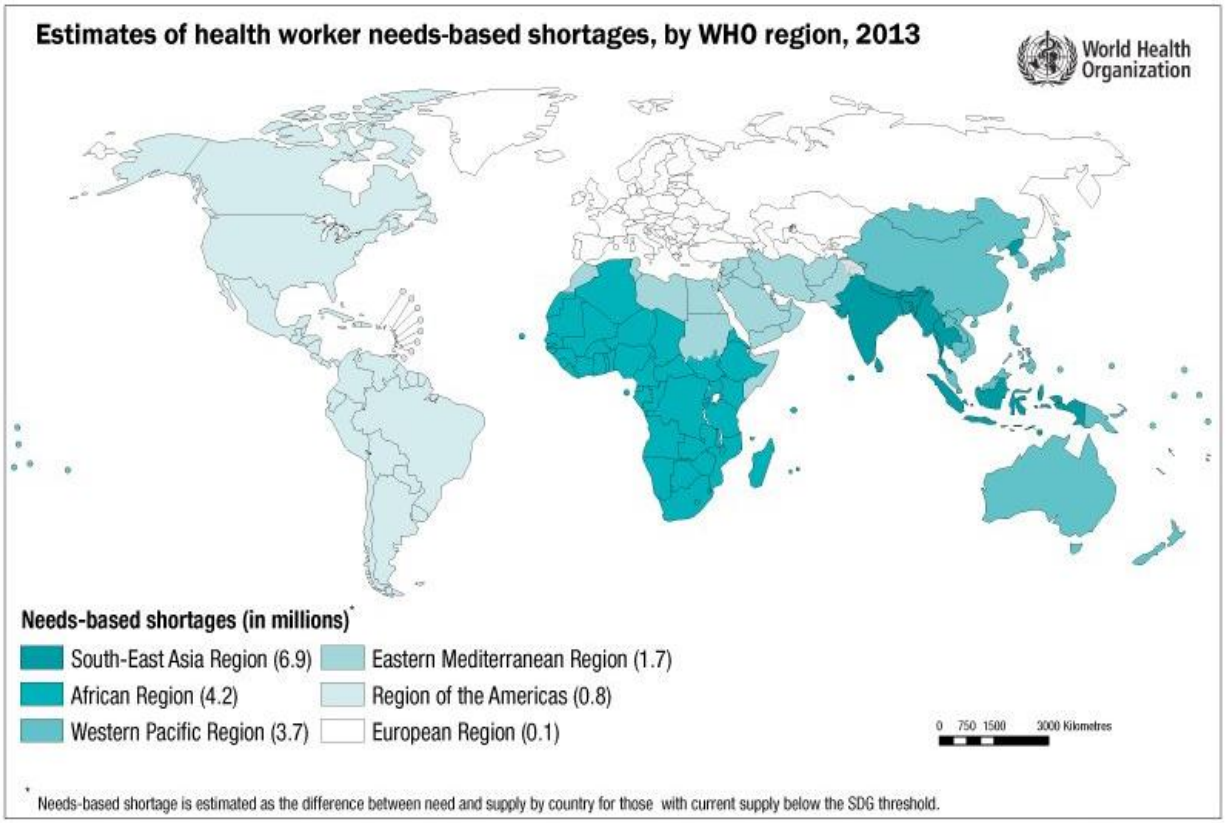
ITU-WHO Focus Group

- However, there are **not enough** healthcare workers to meet demand



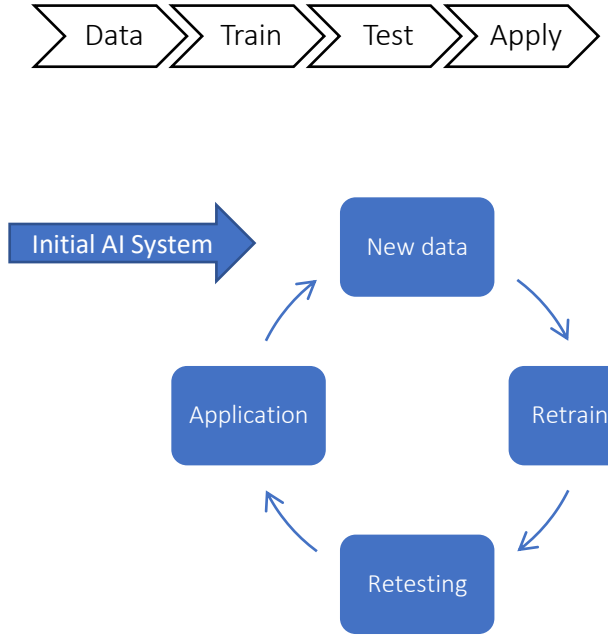
Leverage digital technologies!

- AI solutions can assist with **detection**, **diagnosis**, and medical **decision-making**
- Combine new **machine learning** algorithms with **big data** from electronic health records
- **Internet & smartphones** spread to the most remote corners of the globe

But there are challenges…

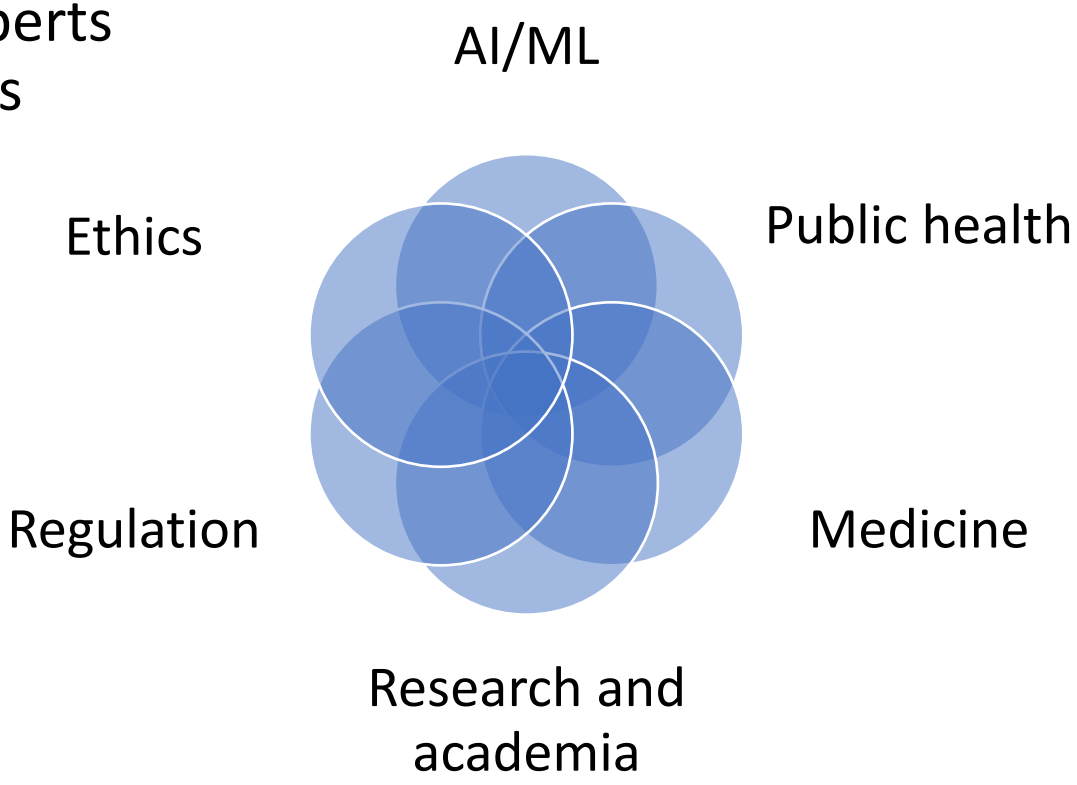
Preliminaries of AI:

- Train once and use (linear deployment)
- Fixed input-output relationship (stationarity assumption)
- Reality of AI:
- Cyclical with updates
- Non-stationarity (data nor input-output)



… that need to be addressed

- Requires a **joint effort** from experts in **diverse** fields including:



AI for Health
ITU-WHO Focus Group

ITU/WHO FG AI for Health

- Established in 2018 as **collaboration** between **ITU** and **WHO** to **address the challenges** of evaluating AI for health
- **Interface** between multiple fields: AI/ML, medicine, public health, government, regulation, statistics, ethics

Who is FG-AI4H?

Leadership:

- Thomas Wiegand, Fraunhofer HHI and TU Berlin, Germany
- Manjula Singh, ICMR, India
- Naomi Lee, The Lancet, United Kingdom
- Sameer Pujari, WHO
- Shan Xu, CAICT, China
- Stephen Ibaraki, ACM, Canada
- Ramesh Krishnamurthy, WHO

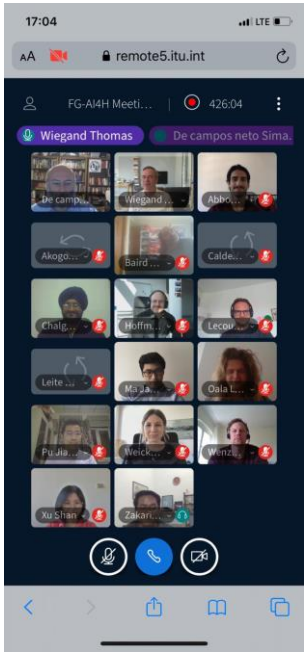
Members:

- Experts from around the globe

Stakeholders and supporters include:

- WHO, ITU, IANPHI, IAP, IHF, AI4Good, WHS, philanthropists (Fondation Botnar), and IMDRF

FG-AI4H collaboration



5/2018 AI for Good Geneva
10/2018 WHO HQ Geneva
11/2018 Columbia University NYC
1/2019 EPFL Lausanne
4/2019 World Expo Shanghai
5/2019 AI for Good Geneva
9/2019 UCSAF Zanzibar
11/2019 ICMR & NICF New Delhi
1/2020 PAHO/WHO Brasilia
~~3/2020 AI in Singapore~~
5/2020 Online
9/2020 Online
1/2021 Online
5/2021 Online

- Online and on-site workshops and meetings

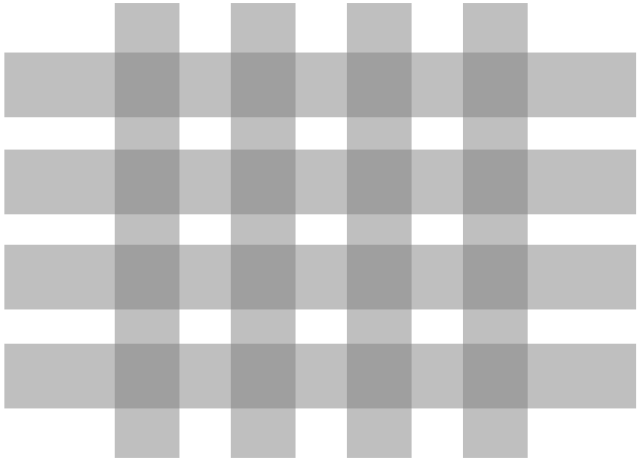
Mandate

- FG-AI4H recognizes that AI offers substantial improvements for public and clinical health
- FG-AI4H supports standardization of AI for health **to foster safe use on a global scale**

Structure

FG-AI4H working groups

Data and AI solution assessment methods (WG-DAISAM)
Data and AI solution handling (WG-DASH)
Ethical considerations on AI4H (WG-Ethics)
Regulatory considerations on AI4H (WG-RC)
Clinical evaluation (WG-CE)
Operations (WG-O)



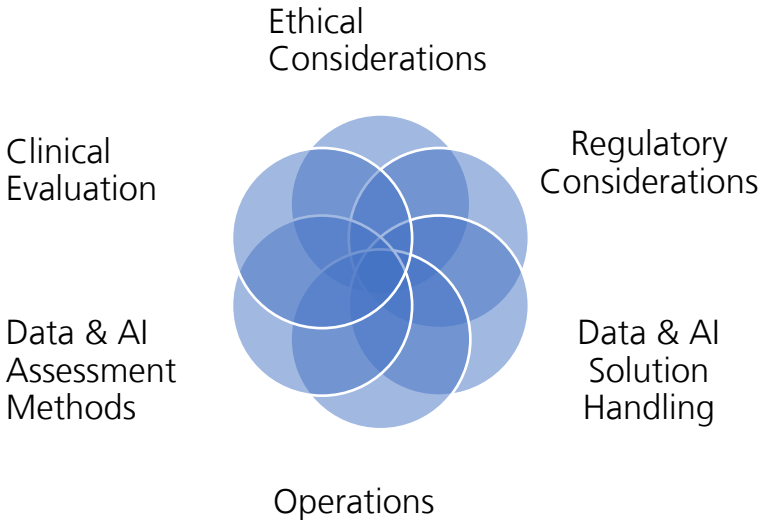
FG-AI4H topic groups

TG-Cardio	TG-TB
TG-Derma	TG-DiagnosticCT
TG-Falls	TG-Bacteria
TG-Histo	TG-Dental
TG-Neuro	TG-Diabetes
TG-Outbreaks	TG-Endoscopy
TG-Ophthalmo	TG-FakeMed
TG-Psy	TG-Malaria
TG-Snake	TG-MCH*
TG-Symptom	TG-Radiology
TG-Fertility	TG-POC°
TG-Sanitation	TG-MSK+

*MCH: maternal and child health
+MSK: musculoskeletal medicine
°POC: point-of-care diagnostics

Working groups

- Dedicated to **overarching themes** that affect all topic groups in a specific aspect of AI for health
- Create **best practices**, establish **processes** and related policies, define ways to successfully **benchmark** AI for health algorithms, and create **reference documents**



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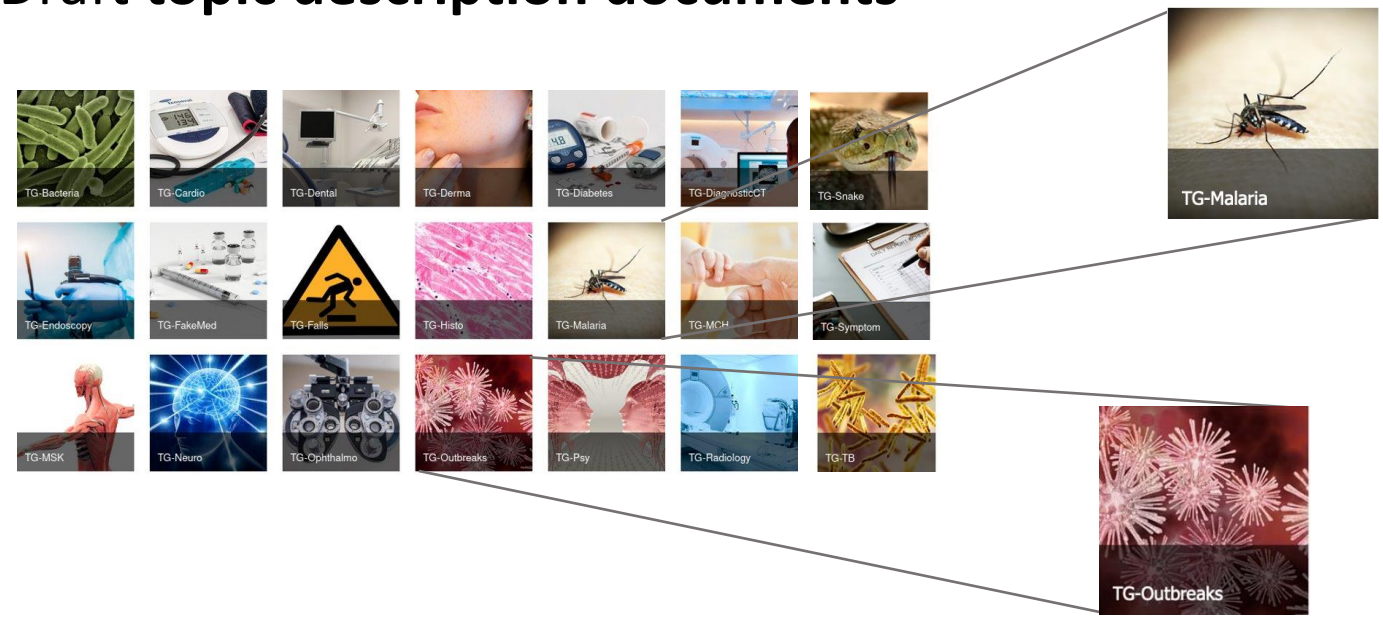
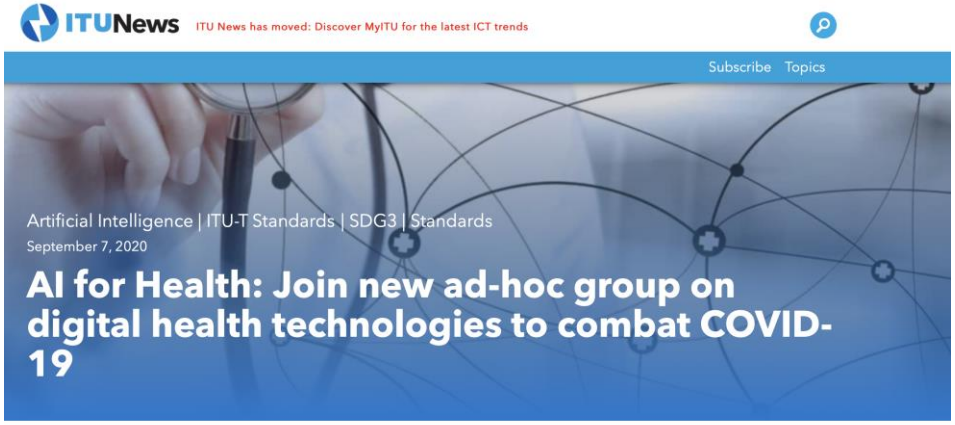
Topic groups

- Dedicated to a **specific health use case** in the context of AI
- Aim at producing **evidence** and **case studies** and bringing together **experts** and **data**
- Propose **procedures to benchmark** AI models for a given task within a health topic
- Draft **topic description documents**



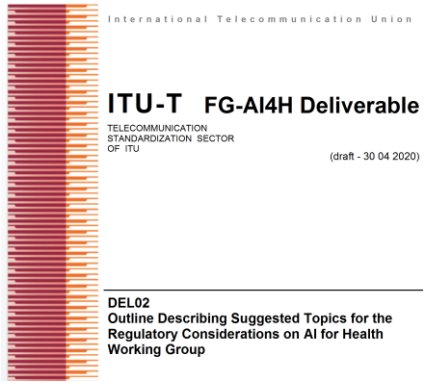
AHG-Digital technologies for COVID health emergency

- Coordinators: Ana Riviere Cinnamond (PAHO) & Shan Xu (CAICT)
- Objectives: Collecting effective ways AI (and related digital technologies) are leveraged throughout the cycle of an **epidemic emergency** using COVID-19 as a case study
- Prevention & preparedness, outbreak early detection, surveillance and response, recovery, rehabilitation, mitigation



Deliverables/documentation

- Address **overarching themes** (e.g., ethical and regulatory considerations, clinical evaluation, and data specifications) or **specific health topics**
- **Updated iteratively** and pass through a rigorous review process
- Provide **requirements** needed to establish the benchmarking process of AI for health


International Telecommunication Union

ITU-T FG-AI4H Deliverable

TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU

(draft - 30 04 2020)

DEL02
Outline Describing Suggested Topics for the Regulatory Considerations on AI for Health Working Group

AI for Health
ITU-WHO Focus Group

Deliverables/documentation

No.	Title
00	Overview of the FG-AI4H deliverables
01	AI4H ethics considerations
02	AI4H regulatory considerations
03	AI4H requirements specifications
04	AI4H software life cycle specification
05	Data specification
06	AI training best practices specification
07	AI4H evaluation considerations
08	AI4H scale-up and adoption
09	AI4H applications and platforms
10	AI4H use cases: Topic description documents

AI for Health
ITU-WHO Focus Group

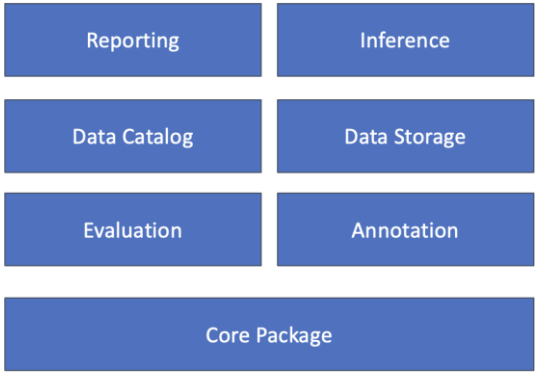
Open-Code-Initiative (OCI)

- Develop **software tools** (e.g., data acquisition, data storage, annotation, prediction, benchmarking/evaluation, and reporting packages)
- Involve **developers**, **regulators**, and **medical professionals**
- Targeted towards a **universal** tool applicable across borders
- Usable by multiple stakeholders such as notified bodies and doctors

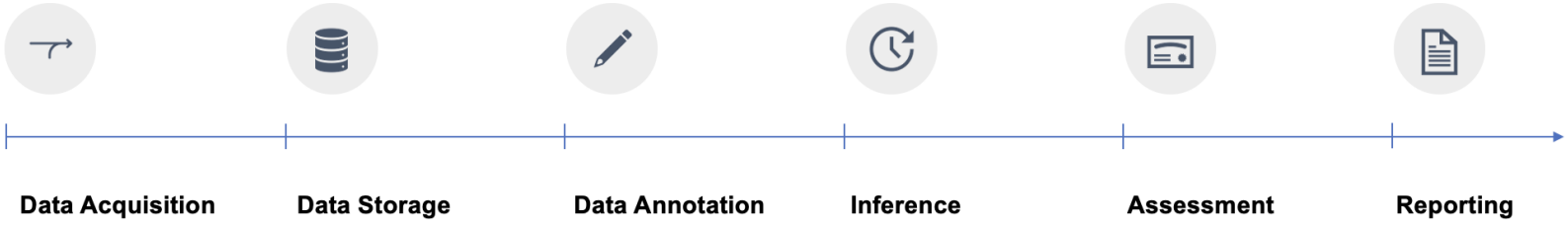
OCI-Collaboration

- International Team
  - 40+ contributors (including WG&TG-members)
  - various backgrounds (engineering, AI/ML-developers, reserachers, academia, medicine, regulation, etc.)

- Structure & workstreams
  - core package
  - data-storage & catalog package
  - data-annotation package
  - evaluation package
  - reporting package



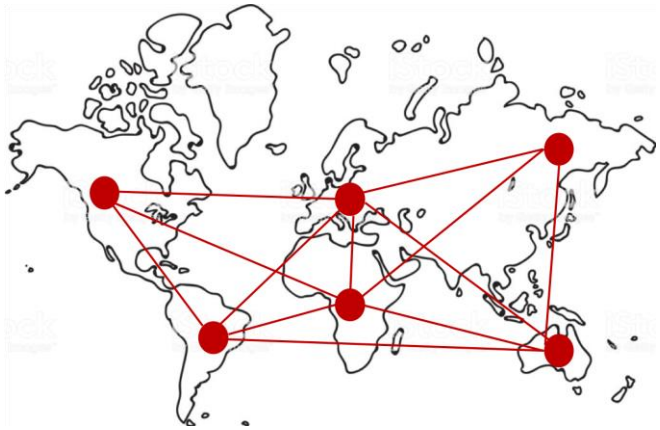
OCI: End-To-end-solution



- OCI platform **focuses specifically on healthcare**
- **covers additional aspects:** ground truth annotation, data - and metadata management, reporting for regulators of AI
- **combines activities & output** of **FG-AI4H working**- and **topic groups**

Data centers

- AI developers/evaluators face a lack of centralized pools of health data
- FG-AI4H is coordinating **compilation of data** in regional centers
- Federated and transfer learning affect AI updates



2021: AI4H-WEBINARS & CHALLENGES

- **AI4H webinars:**
  - Infrastructure of ITU AI for Good Global Summit
  - Most pressing topics on AI & health
  - Renowned speakers, like Regina Barzilay (MIT), Isaac Kohane (Harvard), Jeremy Howard (Fast.AI)
- **AI4H challenges:** coming soon...

AI for Health
ITU-WHO Focus Group

Get involved!

- Join the topic groups, working groups, ad hoc group, and Open Code Initiative
- Contribute to deliverables
- Join mailing list
- Visit FG-AI4H website
- Read *Whitepaper* & commentary in *The Lancet*
- Consult the onboarding document
- Join the AI4H webinar series

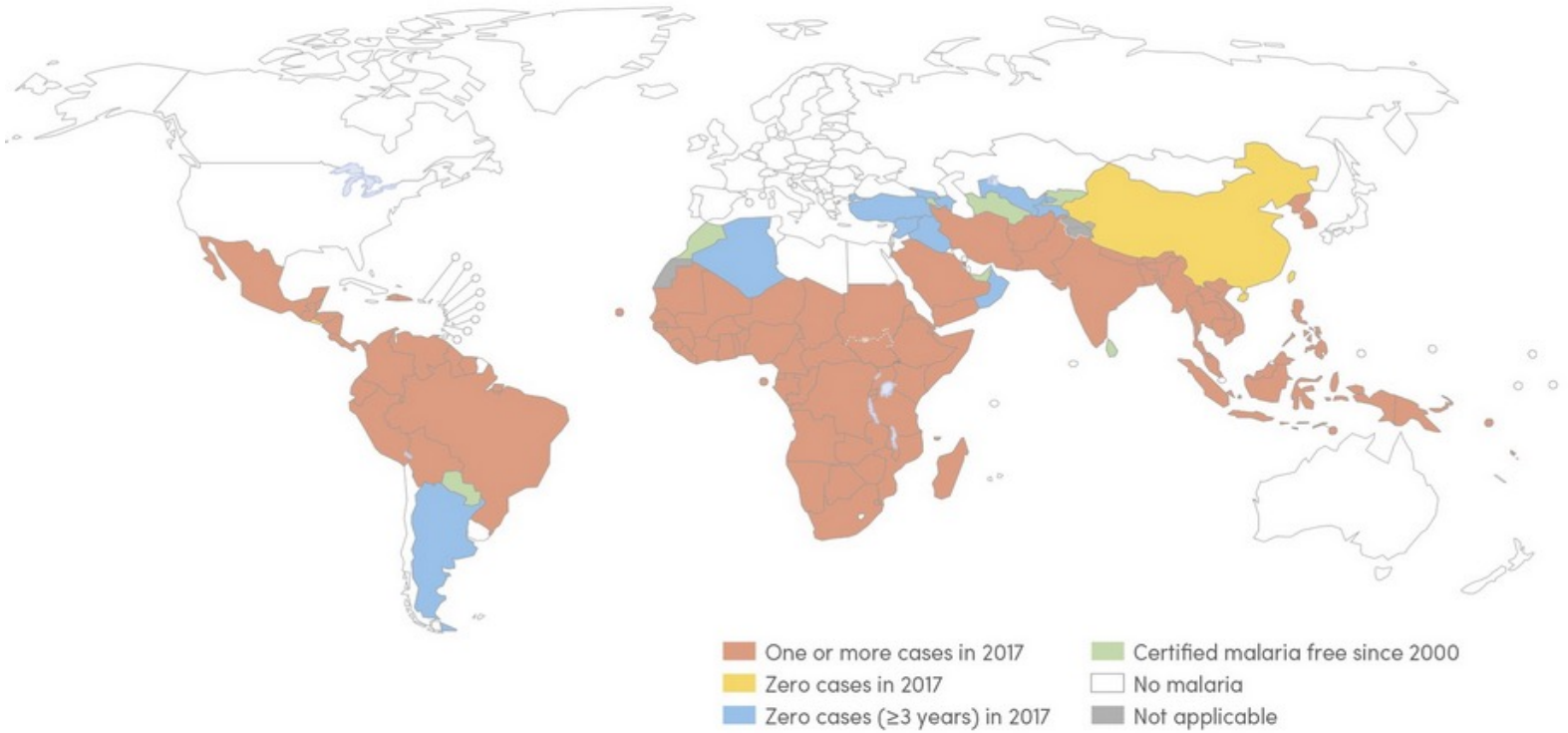
AI Based Detection of Malaria

AI for Health
An ITU Focus Group
In collaboration with WHO

TG-Malaria
Rose Nakasi
Makerere University, Uganda

Emerging Tech-week 5th-9th July 2021

Global malaria burden



•Globally, malaria accounts for over 229 million cases

Malaria burden

Currently in and many developing countries

- Malaria has been reported as one of the leading cause of death
- Patient in big numbers wait to be diagnosed

Microscopy challenge

In highly malaria endemic countries;

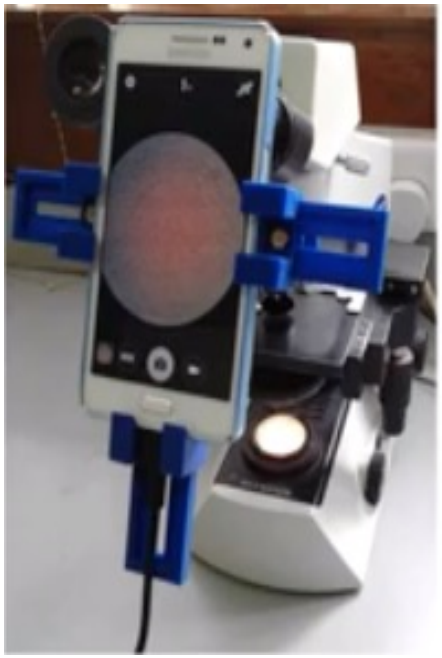
- There is lack of enough trained lab technicians
- In Ghana, 1.72 microscopes per 100,000 population, but only 0.85 trained laboratory staff per 100,000 population

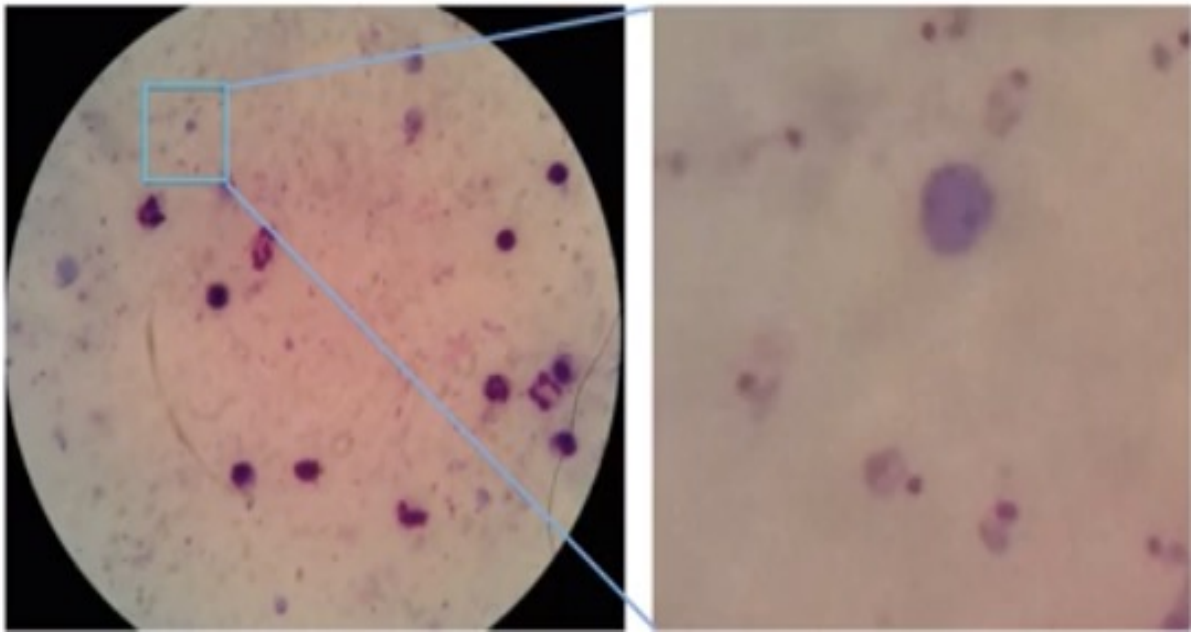
Diagnostic challenge

- Standard Operating Procedure requires not to view more than 30-40 slides a day
- Microscopy is eye straining
- Less diagnosis throughput
- Variations in individual expert judgment

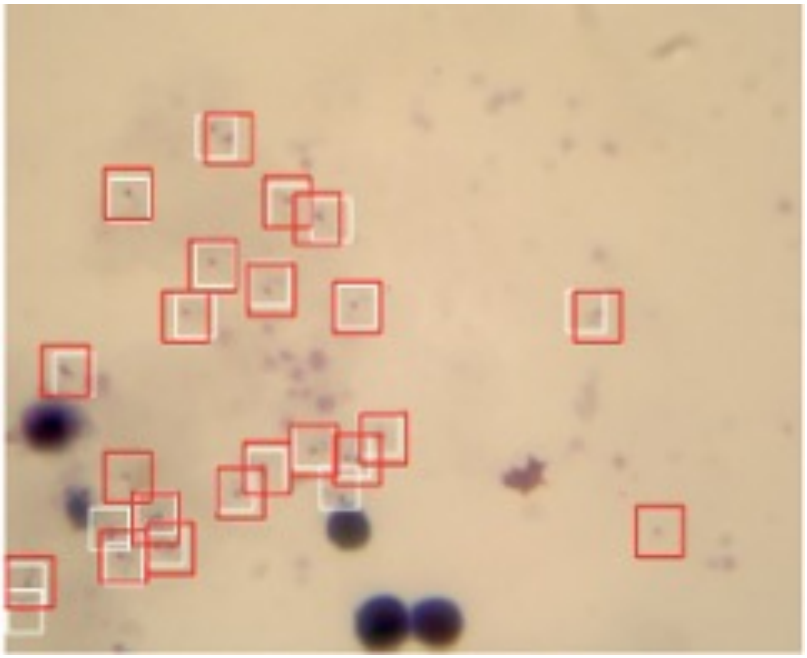
Digital imaging for malaria diagnosis

Set up





Automated detection of malaria



TG-Malaria activities

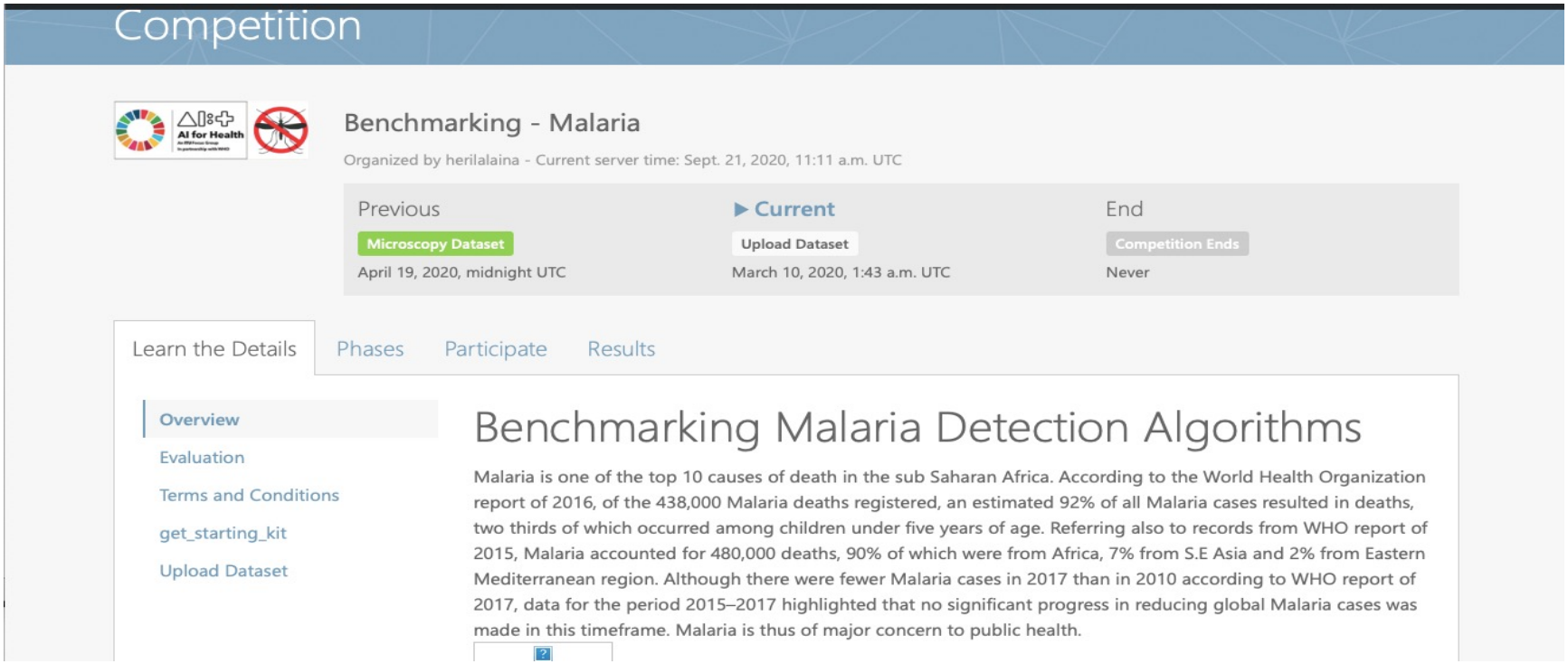
In order to standardize AI based detection of malaria

- **Quality datasets needed**
  - Have more datasets for training and testing
  - Well labelled datasets

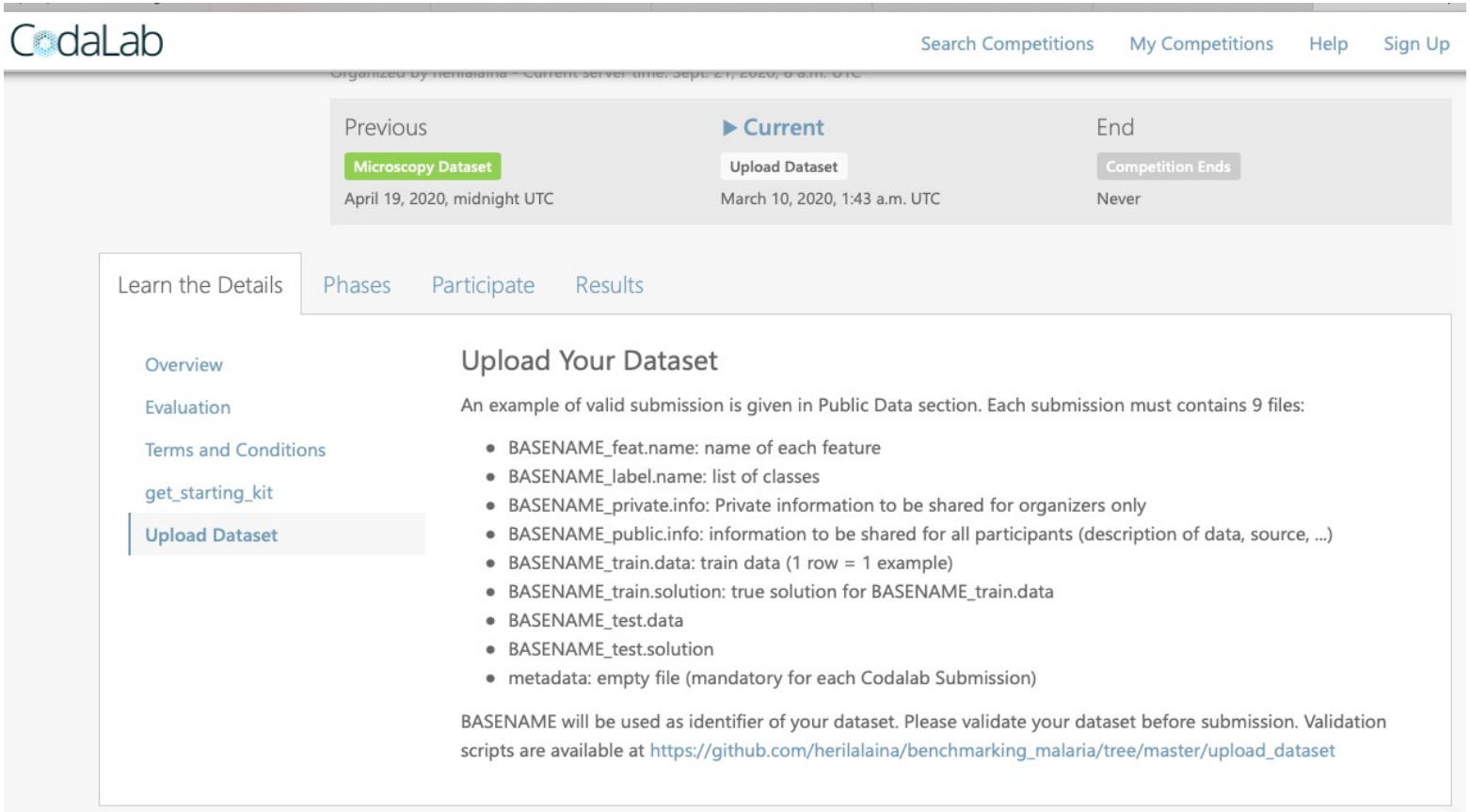
- **Solution**
  - AI models and approaches related to malaria detection.
  - Suggestions on scoring metrics.
  - Improvements on the benchmarking framework.
  - Support to the group on different aspects (data, methods, benchmarking, etc.) of this topic
  - Extension of the solution to improve disease surveillance and prediction.
    - Heterogeneous Data needed

Benchmarking AI-Based detection of malaria

- Benchmarking-Malaria platform

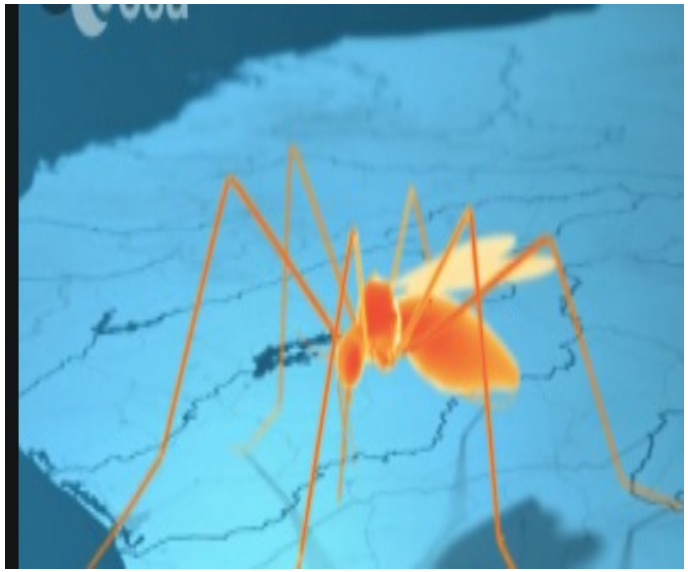


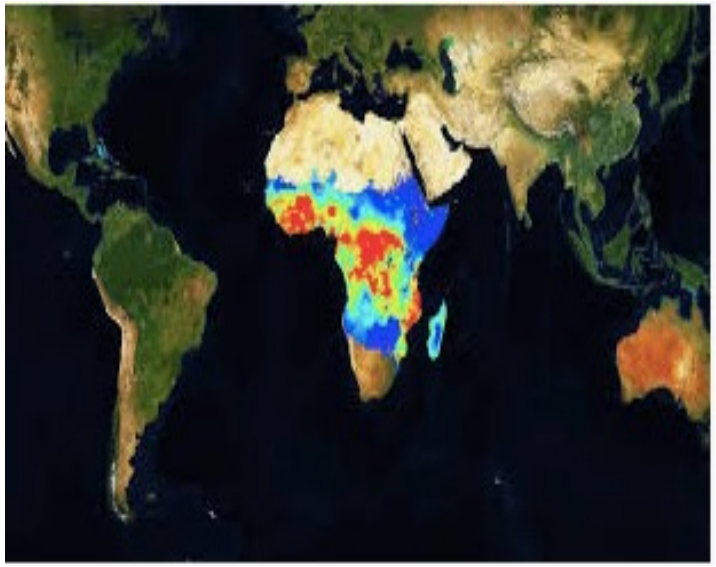
Support for uploading dataset



Sub-topic: Malaria surveillance

Malaria is a bio-hazard





Call for participation

Participation can be in form of:

- Provision of quality labelled data
- **AI models** and algorithms for benchmarking task on malaria
- **General support** on different aspects of this topic (data, methods, benchmarking, etc.)

Contact us

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