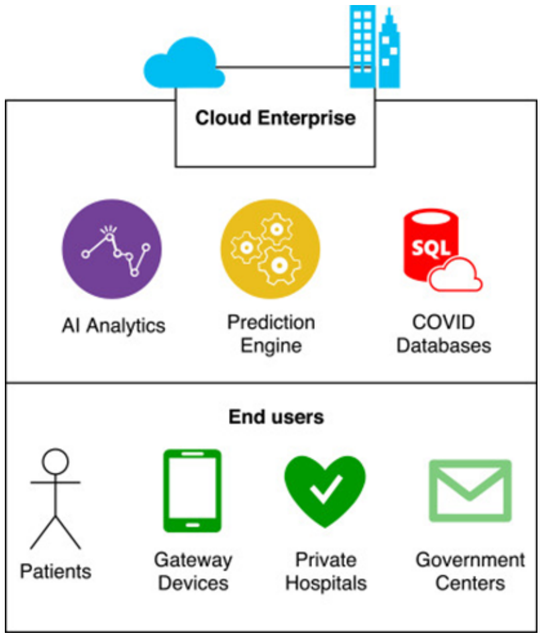
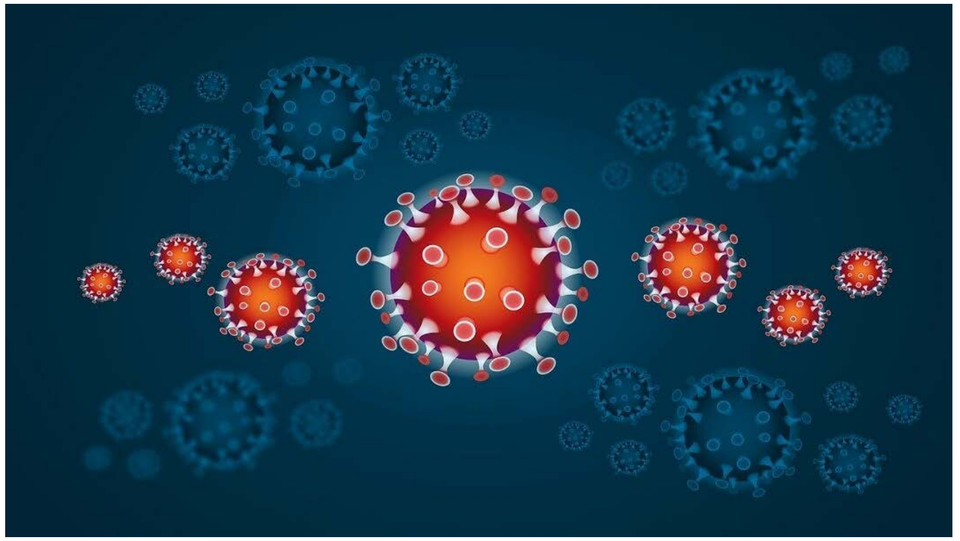
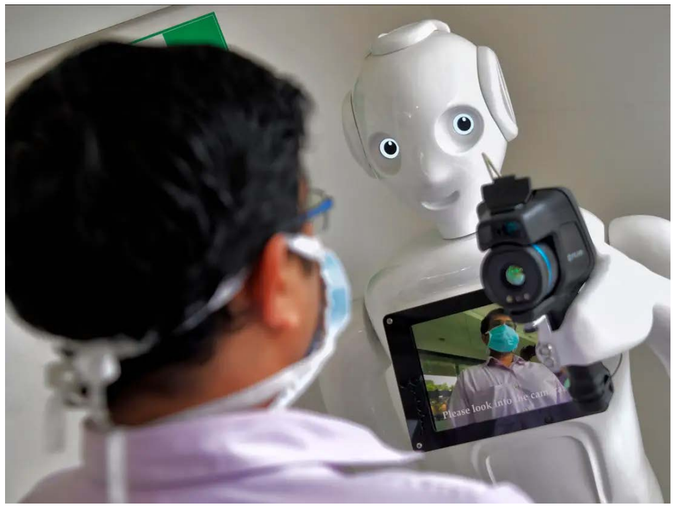
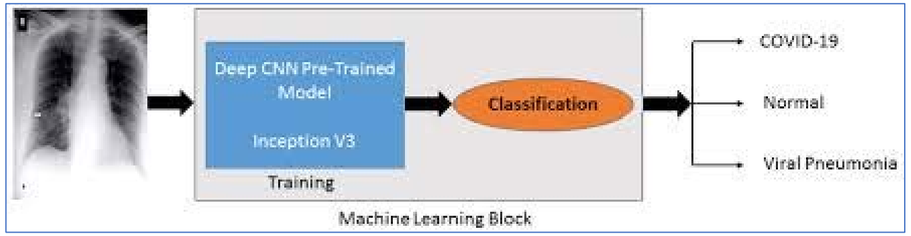
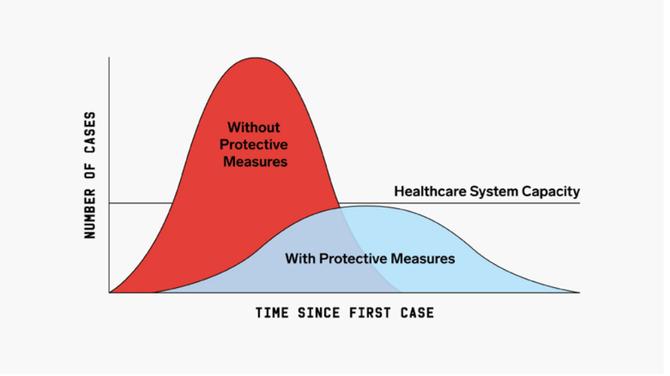
Artificial Intelligence & Machine Learning
In the Times of COVID-19







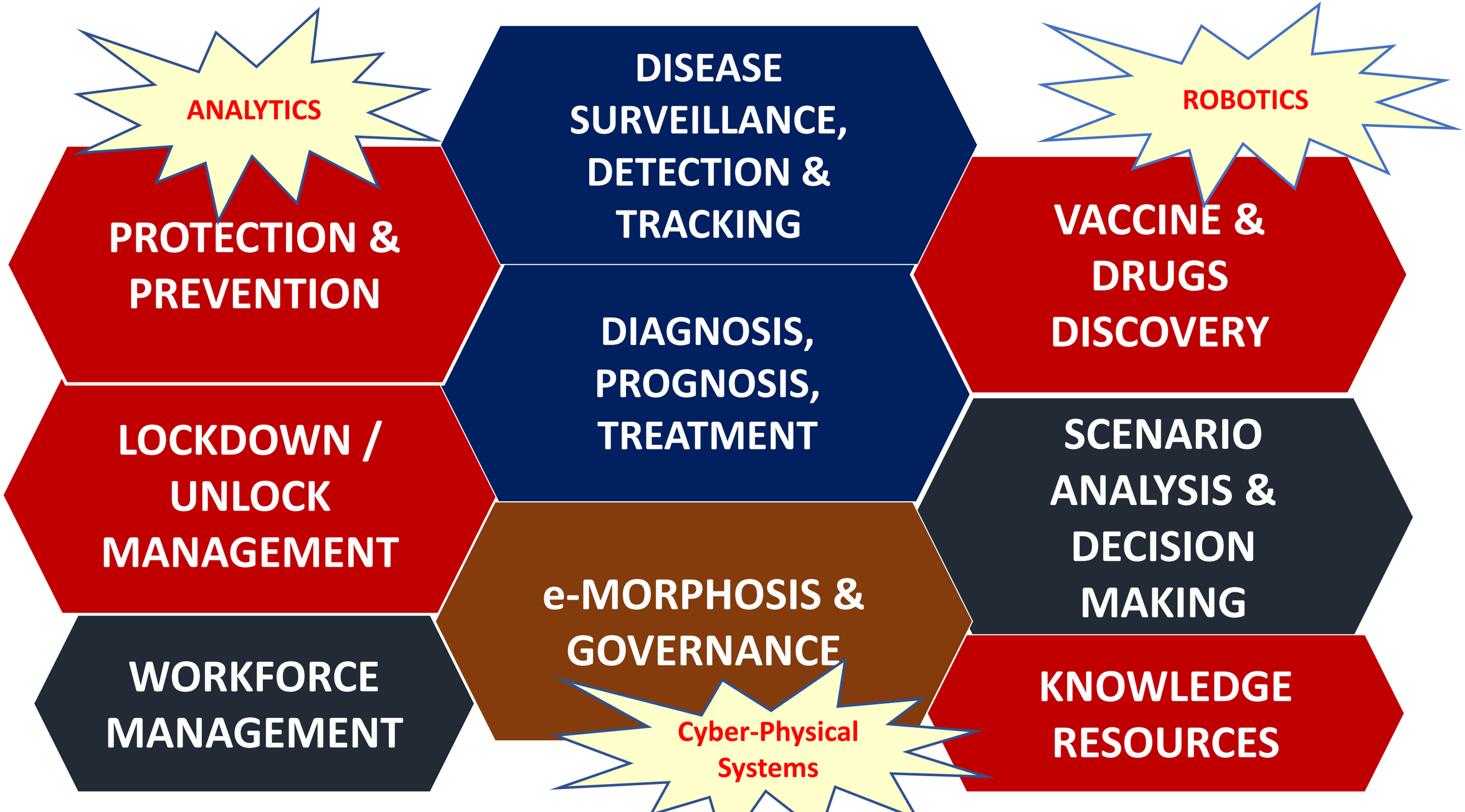




Partha P Chakrabarti

Indian Institute of Technology Kharagpur

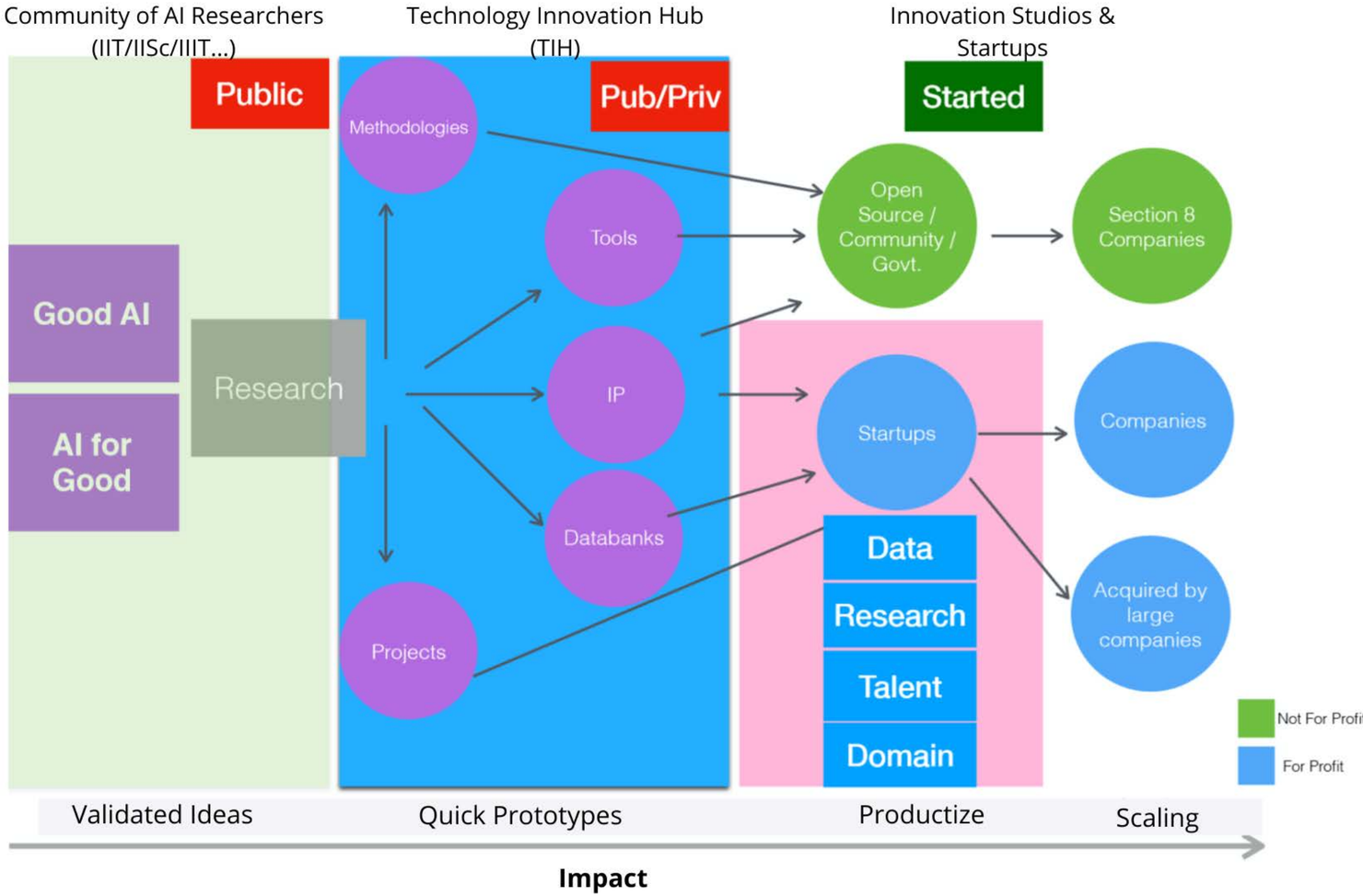
SCOPE FOR ARTIFICIAL INTELLIGENCE IN COVID-19

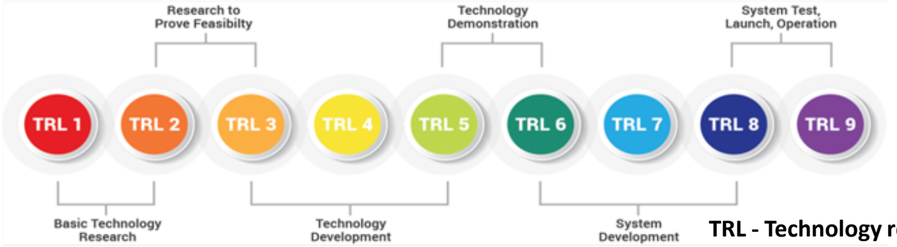


Remedial Action, Knowledge Skimming and Holistic Analysis of COVID-19 (RAKSHAK) Framework

- **Objective**
  - Develop an advanced technology platform connecting all stakeholders i.e., public, doctors, health workers, law enforcement agencies, Govt verticals etc. that facilitates testing, diagnosis, advice, quarantine alert, public alert, remote access and delivery of health advisories
- **RAKSHAK creating technology platform focusing on development and deployment of application based on use cases**
  - AI-driven diagnostics
  - Personalized treatment
  - Early identification of potential pandemics
  - Imaging diagnostics
- **Acting as the focal point and nodal AI Technology Infrastructure**
  - Enabling the ecosystem for application-based technology development, deployment and transfer
  - To take on top-level challenges identified or inter-ministerial projects calling for AI-based solutions
  - Creating databank of COVID-19 related data
    - collect, store, authenticate, and provide access to AI / ML researchers
  - Bringing System integrators together
- **Consortium mode proposal led by IIT Jodhpur**
  - First deadline of proposal submission was 27-Apr-20
    - ~70 submissions received
    - 50 unique submissions shortlisted
    - 8 projects received commitment of financial support after evaluation presentation in first cohort
    - 2nd cohort presentations being planned
- RAKSHAK "Idea to Impact" innovation engine spurring the next generation of companies that are going to be sorely needed for India's post Covid-19 resurgence as a strategic global leader in science and technoloy
- **RAKSHAK is national initiative creating solutions for COVID-19 benefiting our society**

RAKSHAK "Idea to Impact" Innovation Engine



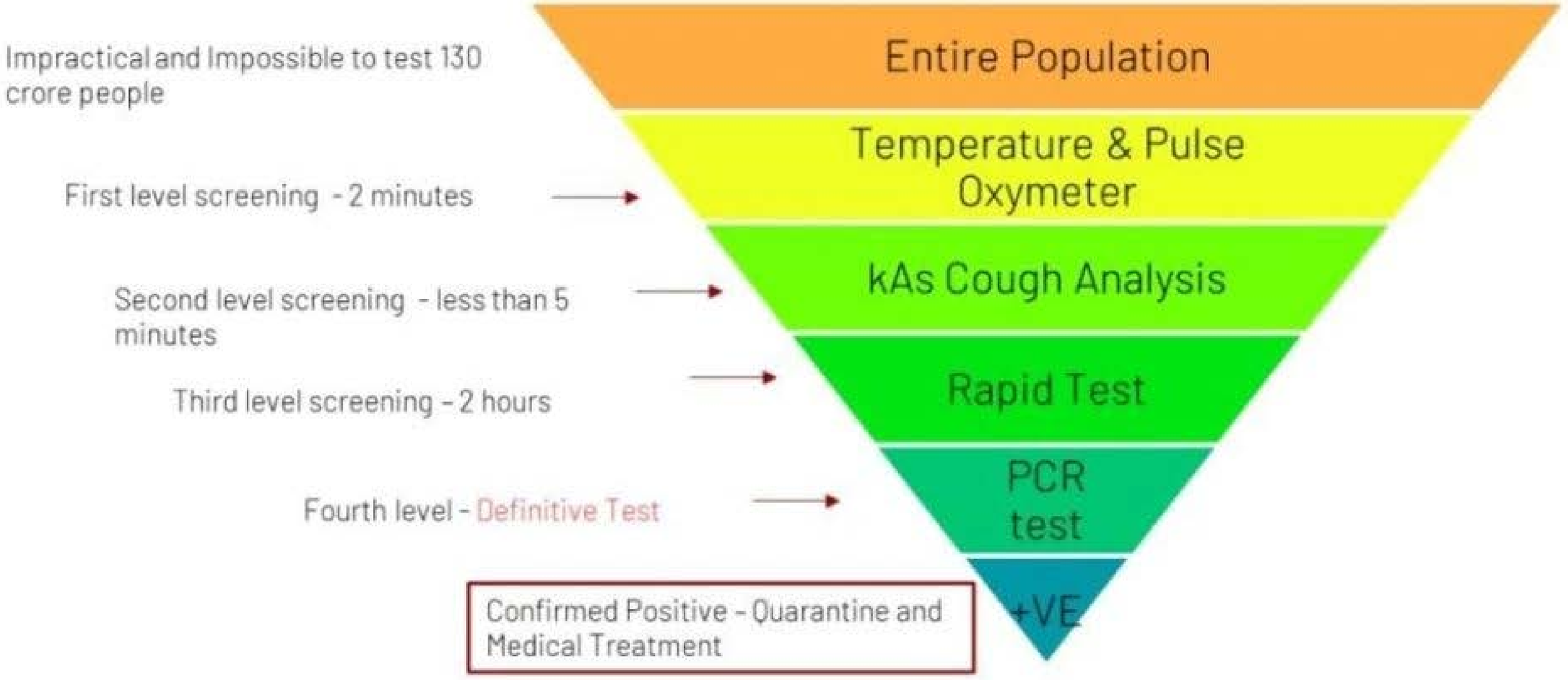


TRL - Technology readiness Level

Coordination Committee

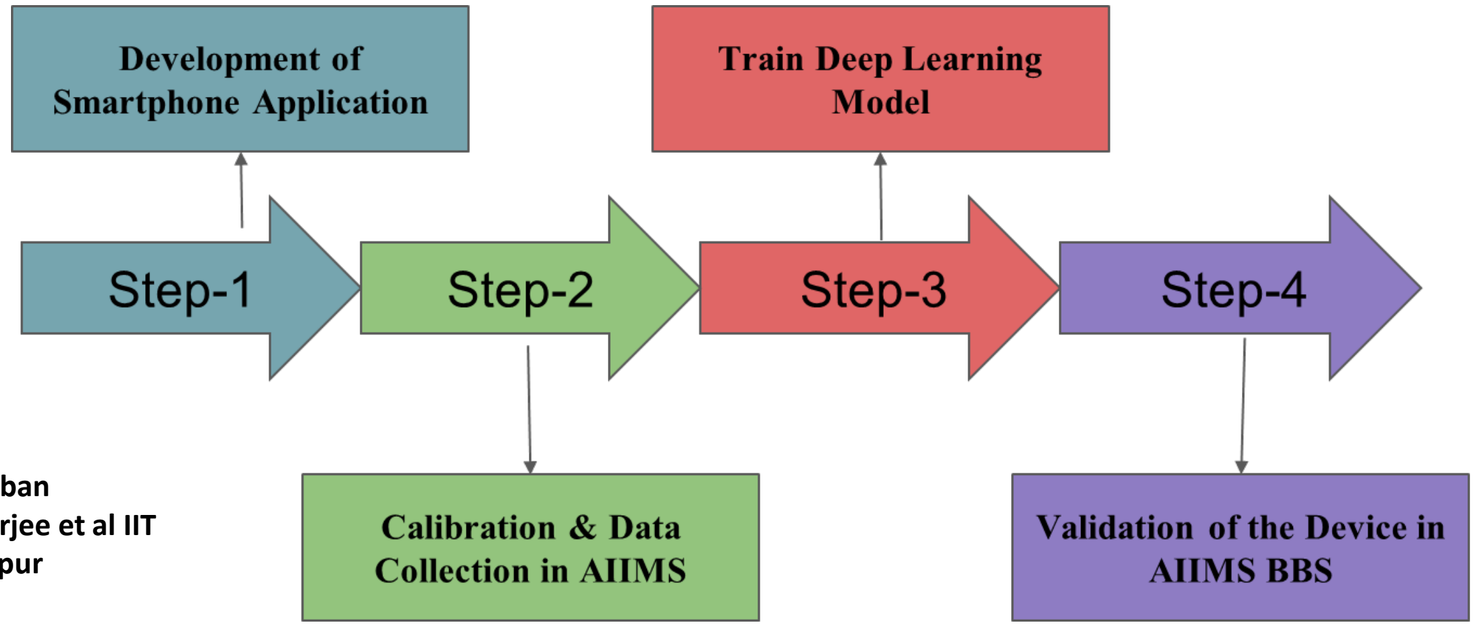
1. Prof. Santanu Chaudhury, IIT Jodhpur
2. Prof. P J Narayanan, IIIT Hyderabad
3. Prof. P. Chakraborty, IIT Kharagpur
4. Shri Umakant Soni, AI Foundry
5. Shri Nandan Mishra, Algo8 AI PVT LTD

COVID-19 Screening Funnel



Deep Learning Spirometry for Health Detection

- Cough detection, Respiratory rate (MIC) and Body temperature (MLX90614) estimation in the smartphone.
- Development of an integrated model to detect the symptoms of chest complications.
- Development of an android application to process the data acquired from the proposed device.



Dr Anirban Mukherjee et al IIT Kharagpur

IIT KHARAGPUR

Coswara - Speech and Sound Based Diagnostics for Covid-19

PI: Dr. Sriram Ganapathy (Asst. Prof. IISc) || Co PI: Dr. Prasanta Kumar Ghosh (Assoc. Prof. IISc)
Electrical Engineering, Indian Institute of Science, Bangalore

Hypothesis

Does Covid-19 leave biomarkers in the voice, speech and respiratory sounds that are detectable?

- Many of the prominent symptoms of Covid-19 include respiratory illnesses and breathing difficulties.
- Many Covid +ve subjects have complained of trouble in sustaining the voice for long periods or having difficulty in speaking at a fast rate.

Methodology

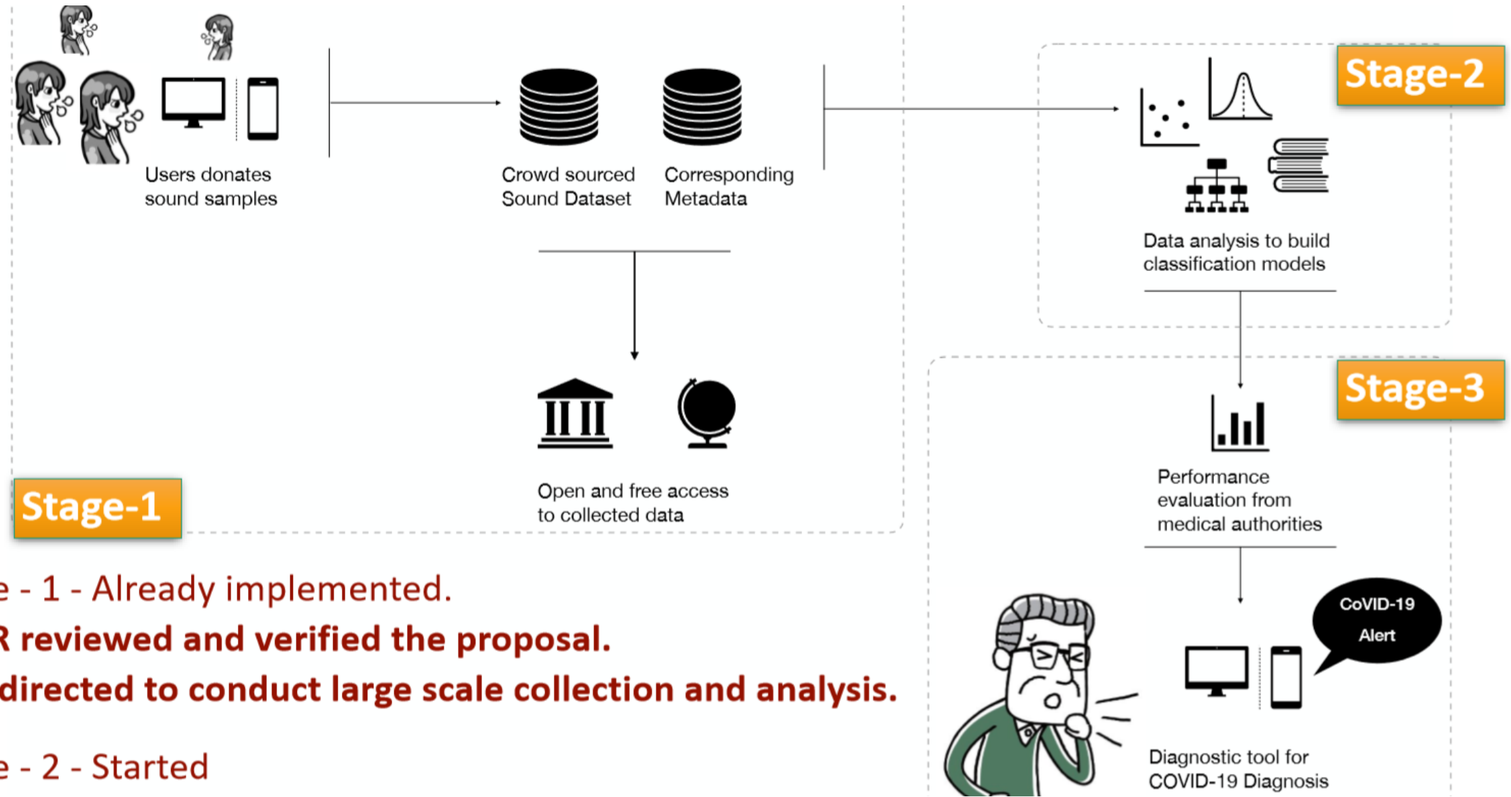
- Collecting sound samples from Covid +ve subjects, subjects with other respiratory illnesses and healthy subjects via webtool
- Developing computer algorithms to experimentally validate the hypothesis.

Pros

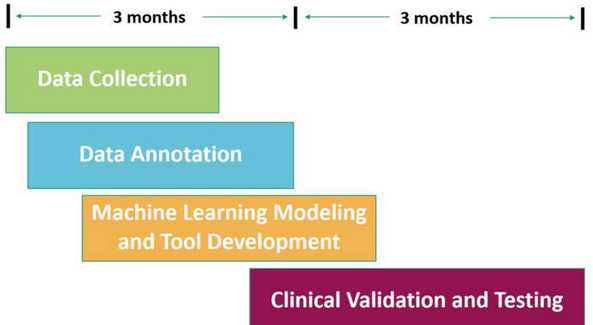
- Simple, fast, cost effective and contactless.

Cons

- If hypothesis is not proved, the data collecte will be useful in future for other respirato sound-based diagnostics.
- In future, this stimuli can also be coupled wi other sensors like pulse rate, body temperatu as well as digital stethoscope-based input.



Work Plan to move to TRL - 7/8



Stage - 1 - Already implemented.

ICMR reviewed and verified the proposal.

And directed to conduct large scale collection and analysis.

Stage - 2 - Started

IoT-based AI-ML for Respiratory Health Monitoring

Prof C S Kumar et al, IIT Kharagpur

Detection of potential cases at home without direct testing saves time and cost and is safe.

Two categories of interest

i. Identification of potential cases for which test is yet to be done

ii. Monitoring of case recovering from Covid attack / treatment in hospital

Non-invasive and self-mode data collection

1. Microphone audio
2. Face mask (smart) / Respirator
3. Chest Expansion using optical sensor
4. IoT enabled ventilator

Physiological symptoms of interest

Shortness of breath / specific breath patterns during normal activities

Low Specific Blood oxygen levels

Monitorable at home / office / commute using portable device + mobile

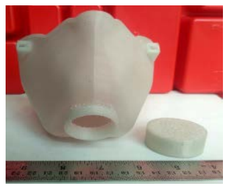
Use of data analytics and AI + ML based classification of potential patients

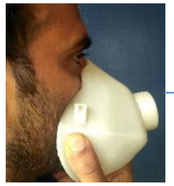
Early warning system development

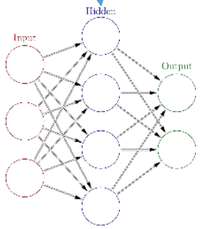
1st Option baseline sound data

Patient data on cloud

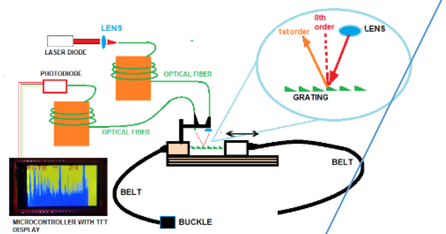
2nd Option breathing data from smart mask



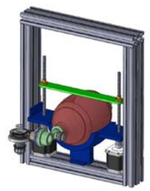


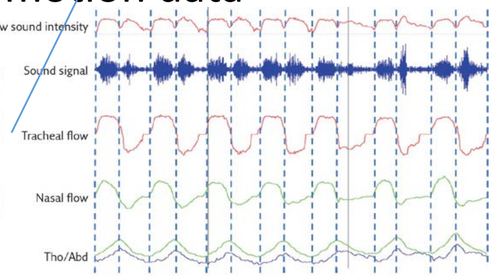


AI & ML



3rd Option chest motion data



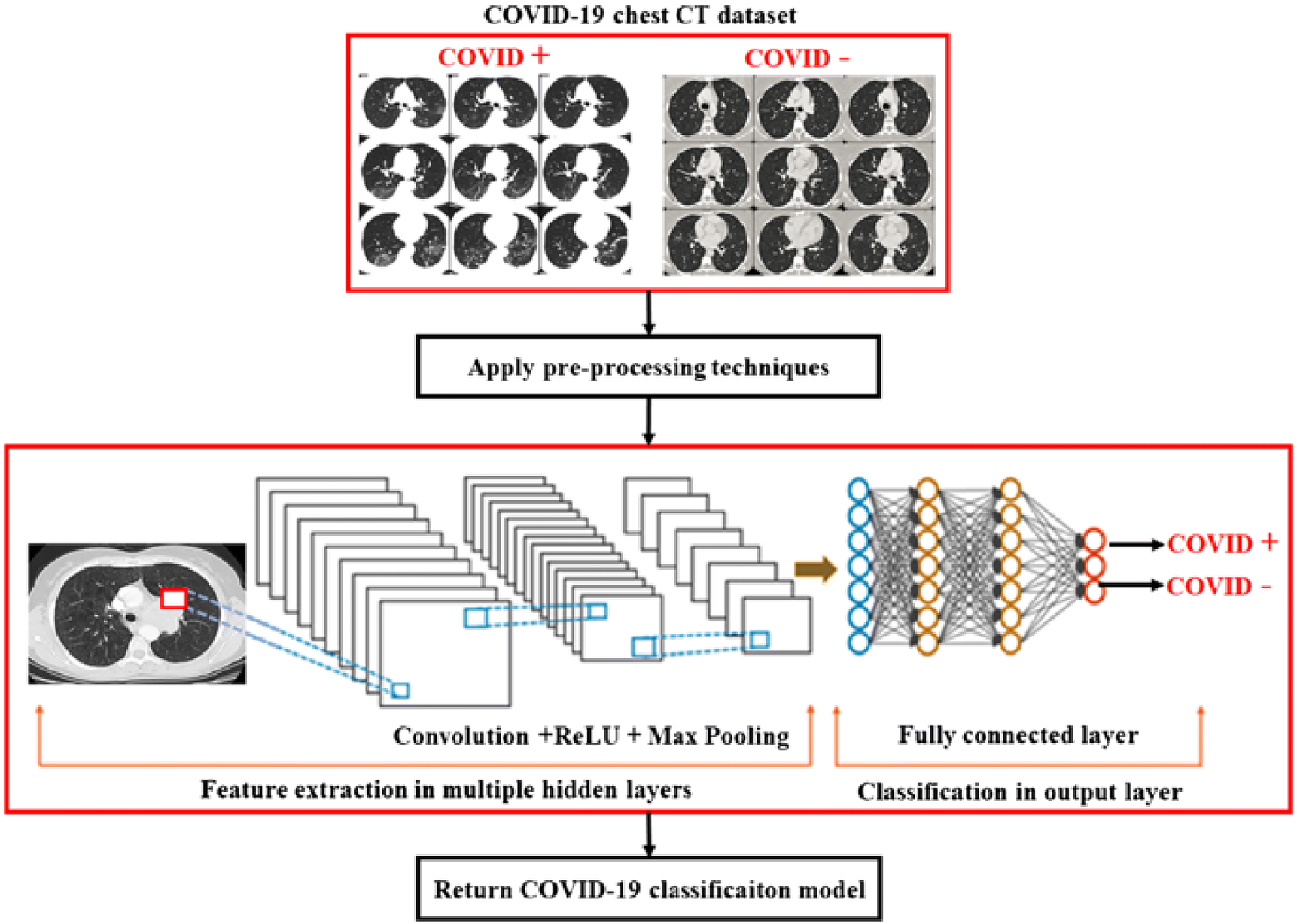


Labelling & Classification

4th Option IoT Ventilator data (post hospitalisation)

IIT KHARAGPUR

COVID Detection Using DL Based X-Ray Image Processing



AI-driven Screening of COVID-19 using Chest X-ray Images, TeleRadiology Solutions

Investigators: Dr Richa Singh, Dr Mayank Vatsa, Dr Santanu Chaudhury || IIT JodhpurCollaborators: Dr. Anjali Agrawal, Dr. Arjun Kalyanpur

Data Collection

- **Healthy x-ray: 10,270**
- **COVID19 x-ray: 389**
- **Other unhealthy x-ray: 21,168**

Data sources:

- **Britain-BSTI, RadioPaedia, India, EuroRad, Spain, Italy, GitHub**
- **Publicly available datasets:ChestXray-14, CheXpert**

AI Algorithm

Multitask Deep Network:

- **Lung segmentation**
- **Semantic segmentation**
- **COVID19 prediction**
- **The algorithm not only provides the predictions but also the regions of interest to make the decisions explainable**

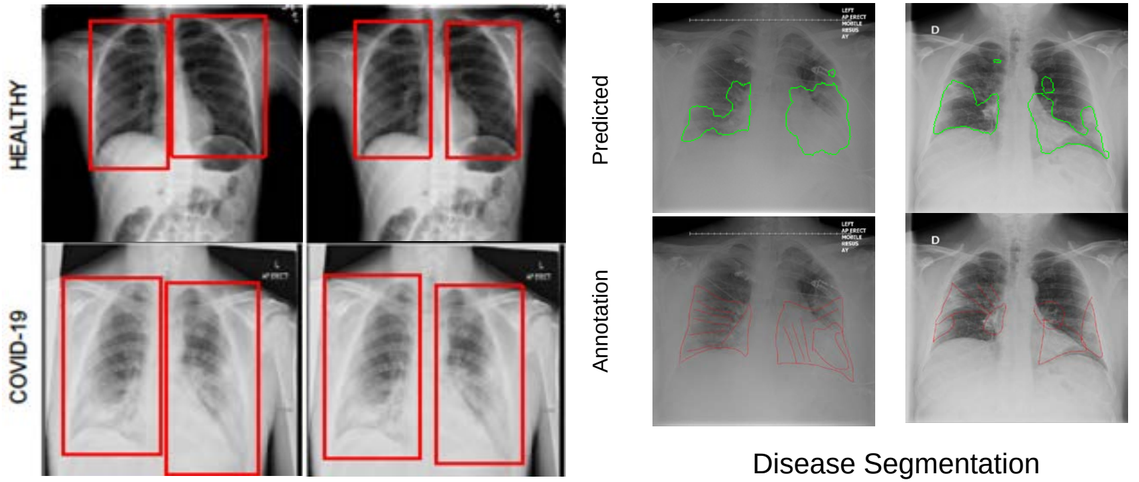
Data Annotation

- **Disease segmentation: 196 COVID19 samples annotated by doctors**
- **Lung segmentation: 10,000samples (assisted by doctors)**

Computational Evaluation

COVID19 vs Non-COVID19

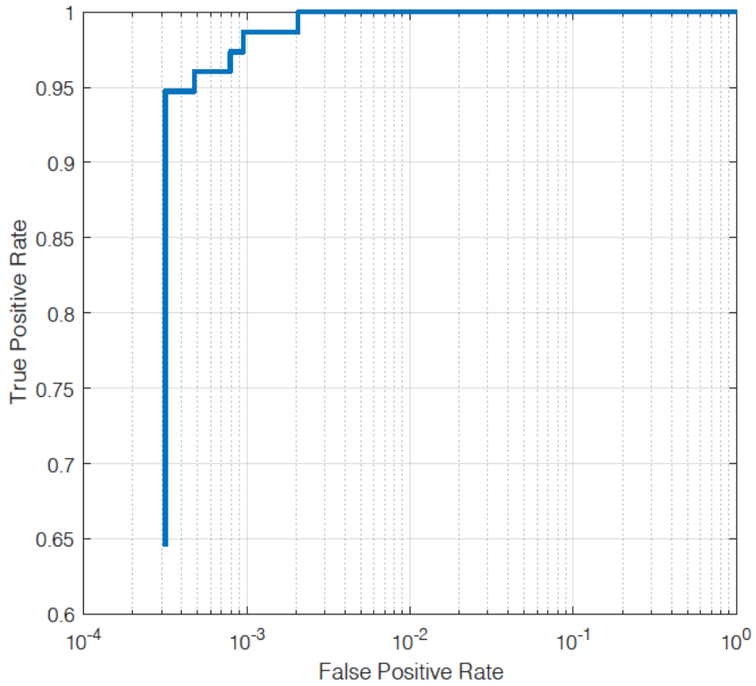
- **Sensitivity = 0.9605**
- **Specificity = 0.9992**
- **AUC: 0.9997**



Disease Segmentation

Partnerships

- Dr. Ashwin Pudrod, Pulmonologist, Maharashtra
- Mahajan Labs
- University Hospital Morales Meseguer, Spain
- University of Chieti, Italy



COVID vs Non-COVID

TRL 6 in 3 months

- Collaborate with hospitals and radiology labs
- Refinement of the system with additional data
- Evaluation of results by domain experts

TRL 7 in 6 months

- Partner with startup to build the online system
- Testing and validation by domain experts
- Evaluation by ICMR

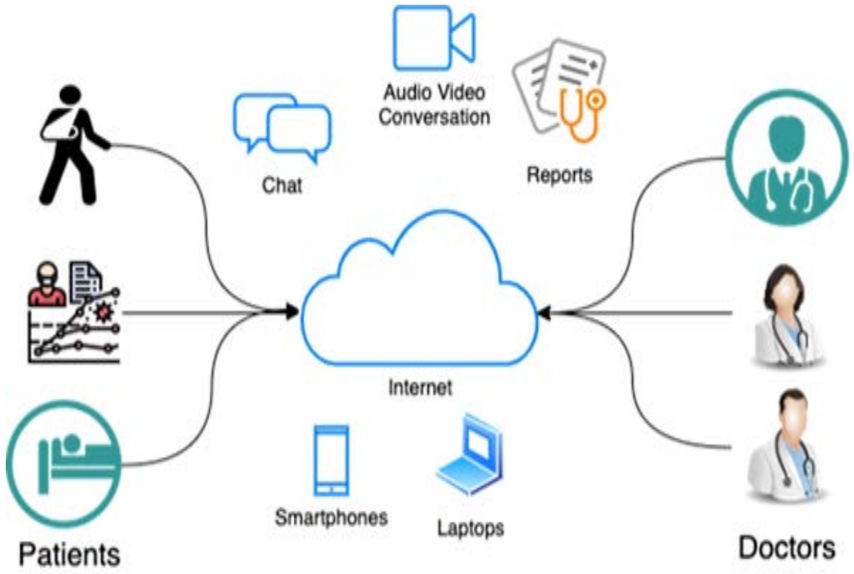
Smart Health Solution for Rapid Mass Screening using Integrated TeleMedicine

PI: Dr. Sumit Kalra, IIT Jodhpur || Co PI: Dr. Rajendra Nagar & Dr. Anil Kumar Tiwari, IIT Jodhpur || Industry Partner: Ampersand Group

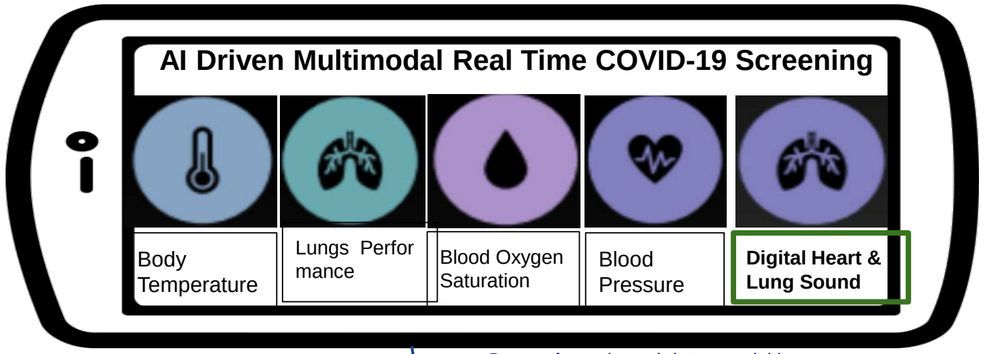
TRL 4 to 7 in 6 Months || Industry Partner: Ampersand Group

Currently: TRL 4

- Identified relevant data sources that will be crucial for the AI-model development
- Validation of Lung sound classification has been conducted using open dataset
- Started the data collection and annotation process from various open sources as well as through partnerships

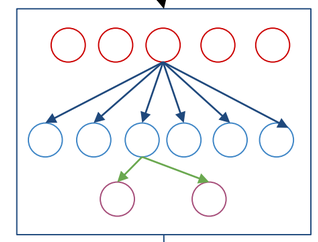


- Deployed at IIT Jodhpur PHC: *https://telemedicine.iitj.ac.in/*
- 40+ doctors are registered on the portal that includes experts with various specialties
- ~250 patients have visited the portal and contacted the doctors
- ~4K visits & <10% consumption of computing resources



Smartphone based data acquisition (work-in-progress)

TeleMedicine Portal



- Digital X-ray based screening
- Acoustic features of breath, cough, and speech based screening
- Smell and taste perception based screening
- Generalize to non-covid scenarios

Future Extensions

COVID Suspect

Non-COVID

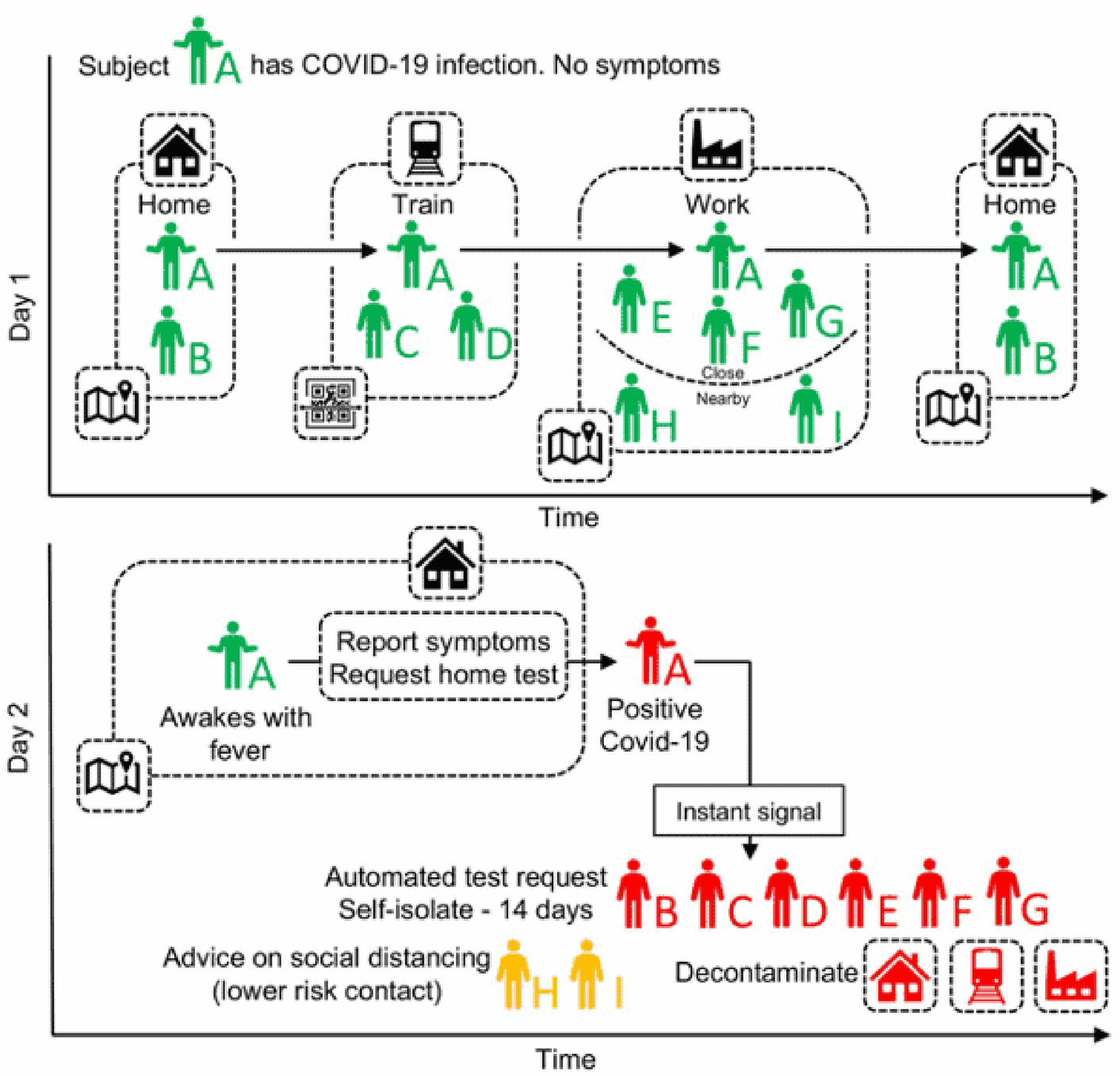
TeleMedicine Portal

TRL 5
Validation on ground
Within 1 Month

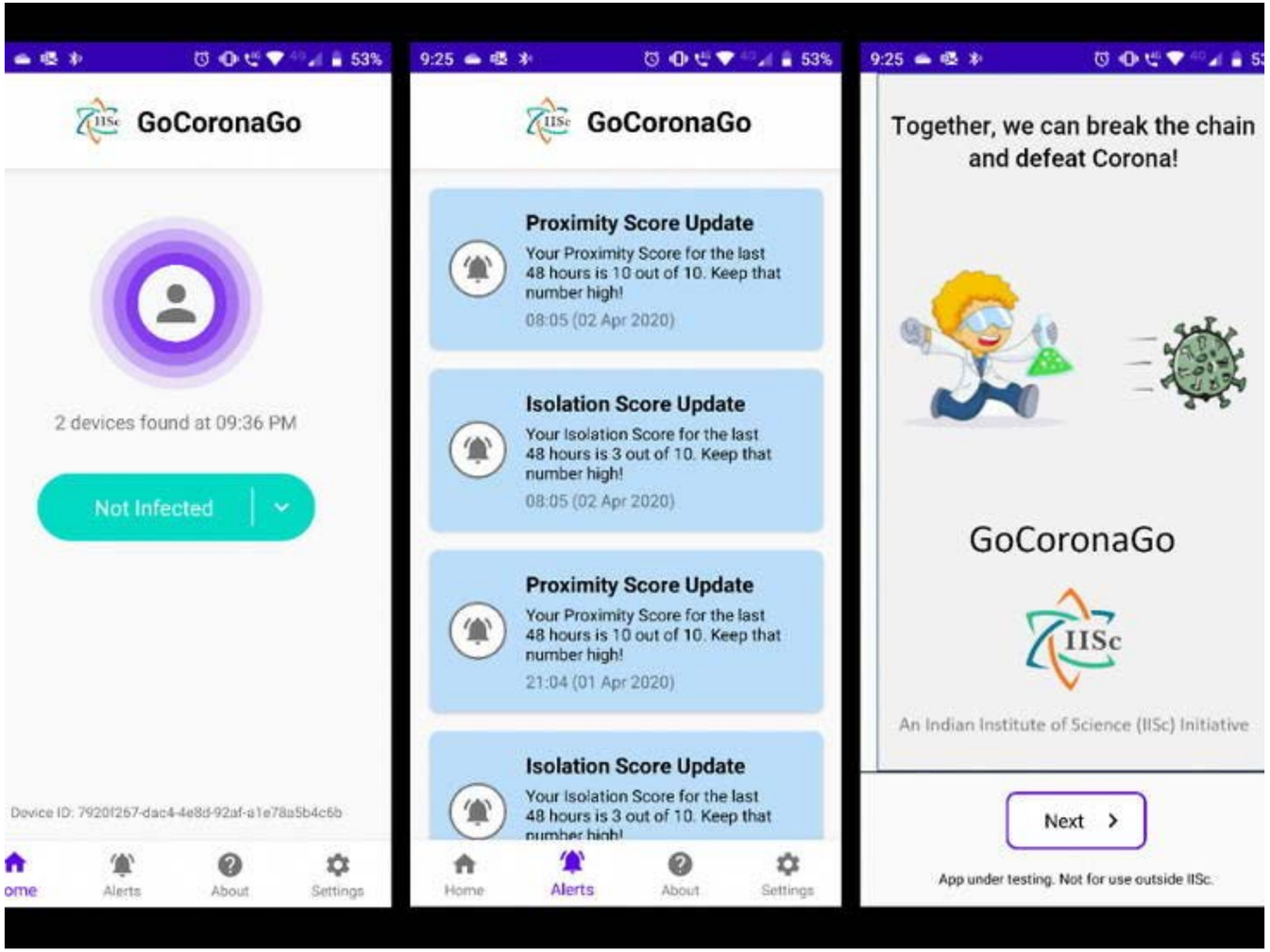
TRL 6
System/subsystem model on ground
Within 3 Months

TRL 7
System prototype demonstration on ground
Within 6 Months

Contact Tracing



COVID Trackers



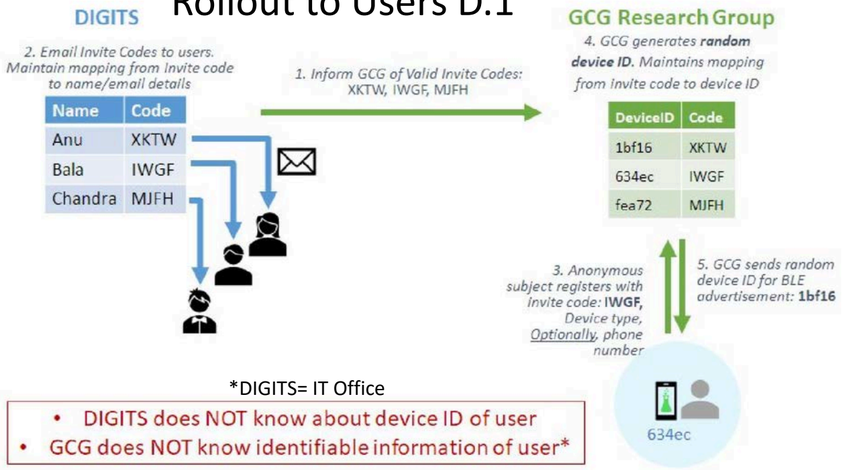
Go Corona Go (GCG)

Dr Yogesh Simmhan and Dr Tarun Rambha, Indian Institute of Science, Bangalore

GoCoronaGo (GCG) is a digital contact tracing app for COVID-19 management at the organizational scale

High Level Workflow of GCG (Deployment at IIT Jodhpur)

Rollout to Users D.1

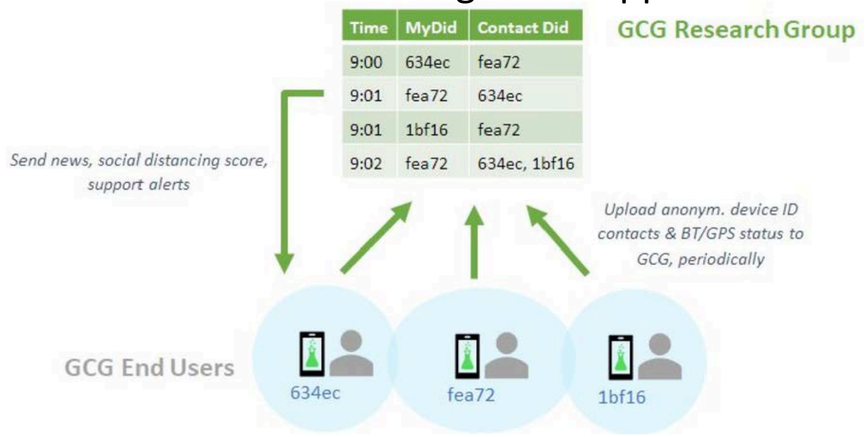


*DIGITS= IT Office

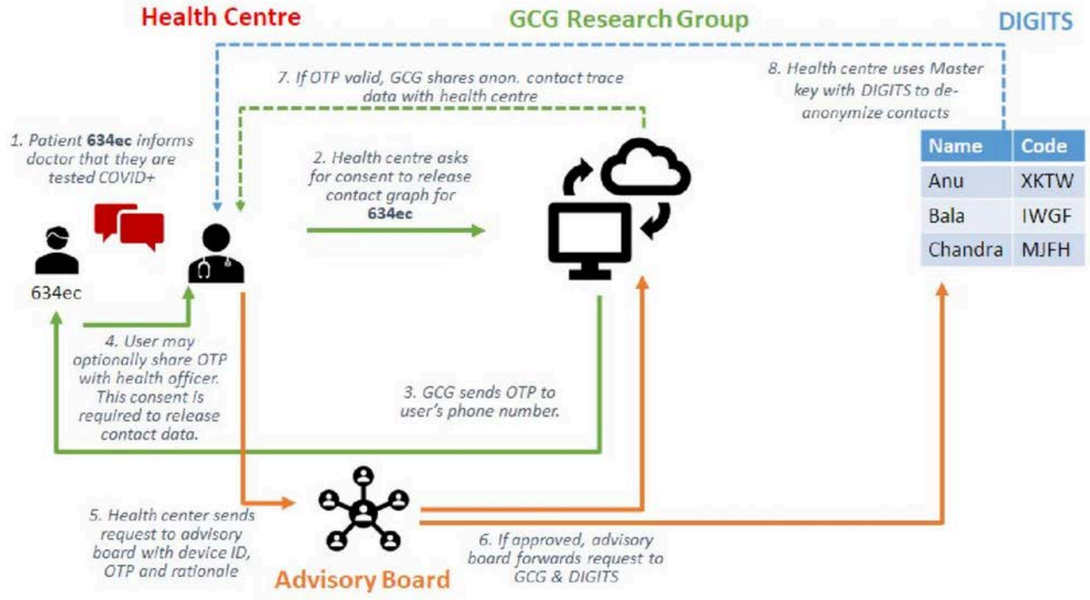
- DIGITS does NOT know about device ID of user
- GCG does NOT know identifiable information of user*

- GCG collects the anonymized Bluetooth proximity data of all app users in the organization in a centralized database
- All members who are affiliated with the host institution, or physically stay on campus are end users

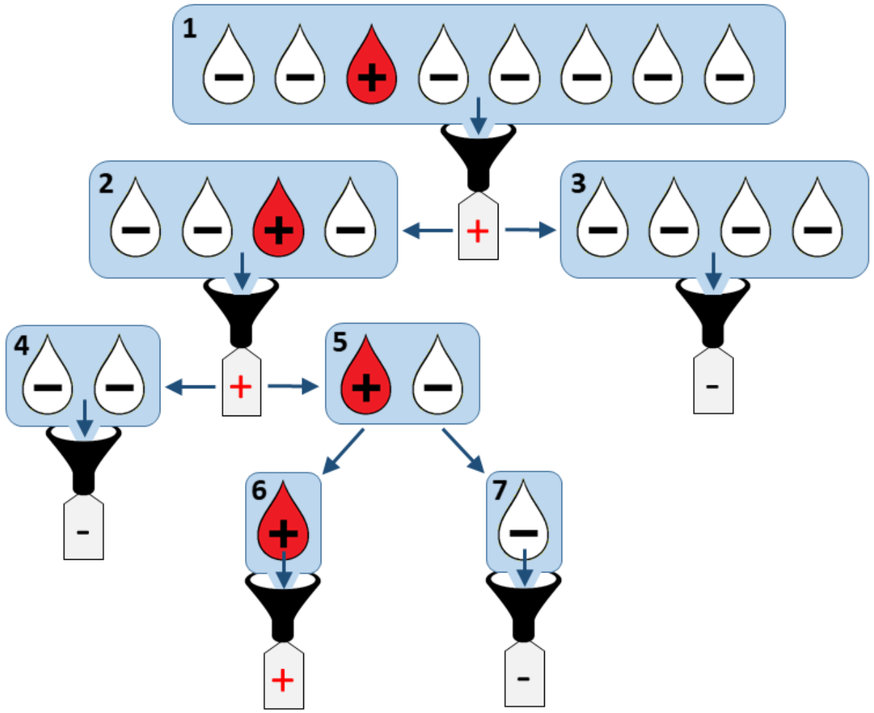
Contact data collection from End Users through GCG App D.2

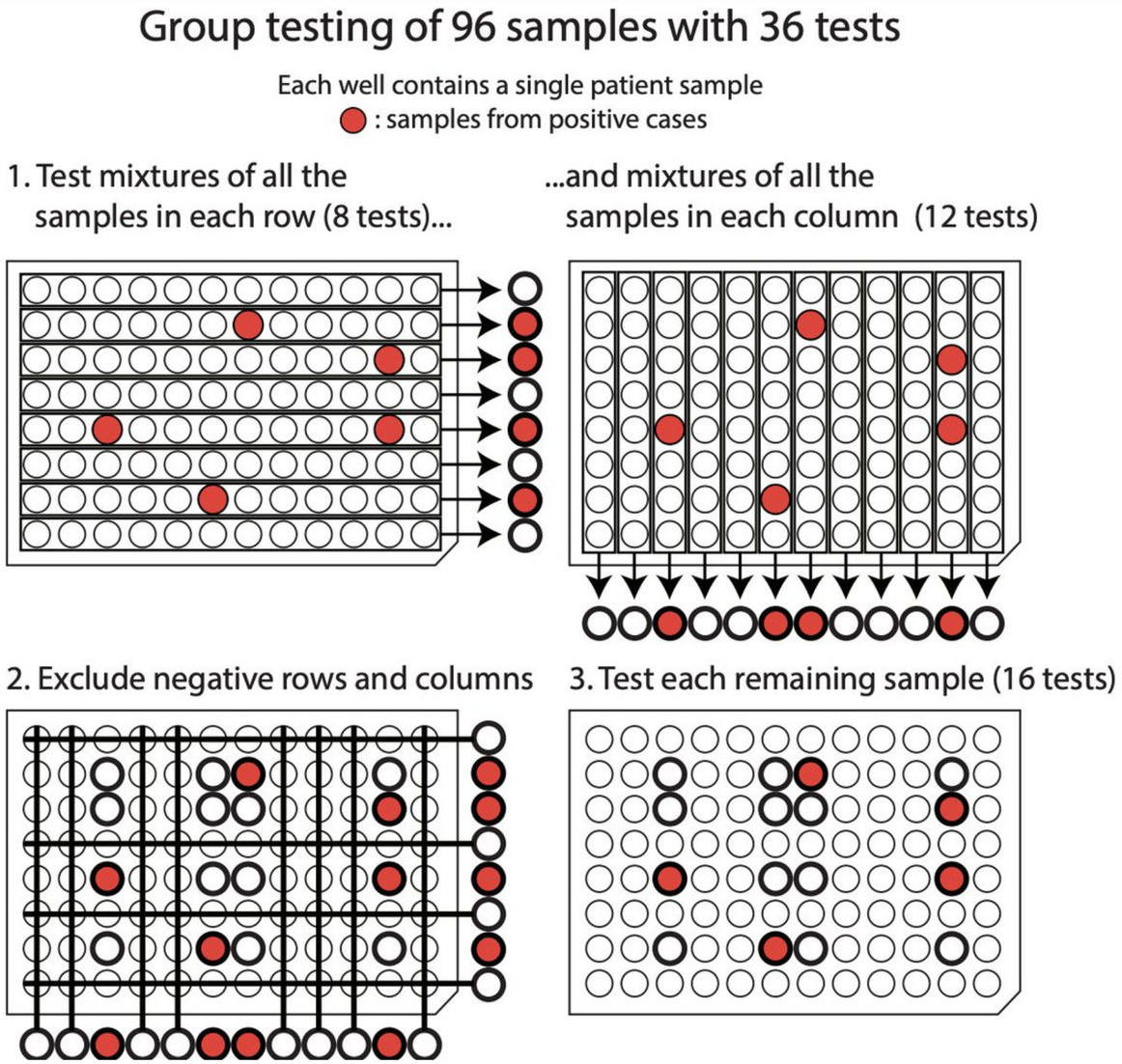


Contact Tracing D.3



Group / Pool Testing Methods





Compressed Sensing for Pooled Covid-19 Testing

IITB PIs: Dr Ajit Rajwade (CSE) and Dr Manoj Gopalkrishnan (EE)

Collaboration between IITB and NCBS-Instem, Harvard, Tata Memorial Hospital, Malabar Cancer Center

Methodology

- Nonadaptive combinatorial pooling of samples along with algorithmic reconstruction using compressed sensing.
- Increasing throughput of testing and conserving reagents
- Redundancy of each sample being simultaneously tested in multiple tests exploited to detect and correct human errors in sample collection & pipetting

Experimental Validation

- 40 samples spiked with RNA were tested in 16 (or sometimes 24) qPCR tests according to the designed pooling method
- Repeating test three times, with up to 5% samples spiked positive.
- Algorithm receiving only the blinded test values, without information on which samples were spiked
- Reconstruction of the positive samples with ~zero false negatives and very few false positives.
- Outperforming baseline techniques such as Dorfman pooling by requiring half the number of tests (on an average).
- Android app to facilitate the work of technicians.
- Single round decision on every sample & each sample goes to only 3 test
- MoU approved between IITB and NCBS-Instem/TMH/MLCC with IRB clearance
- Algorithms have already been tested on lab data and extensive synthetic simulations.
- Approaching ICMR and FDA for approvals.

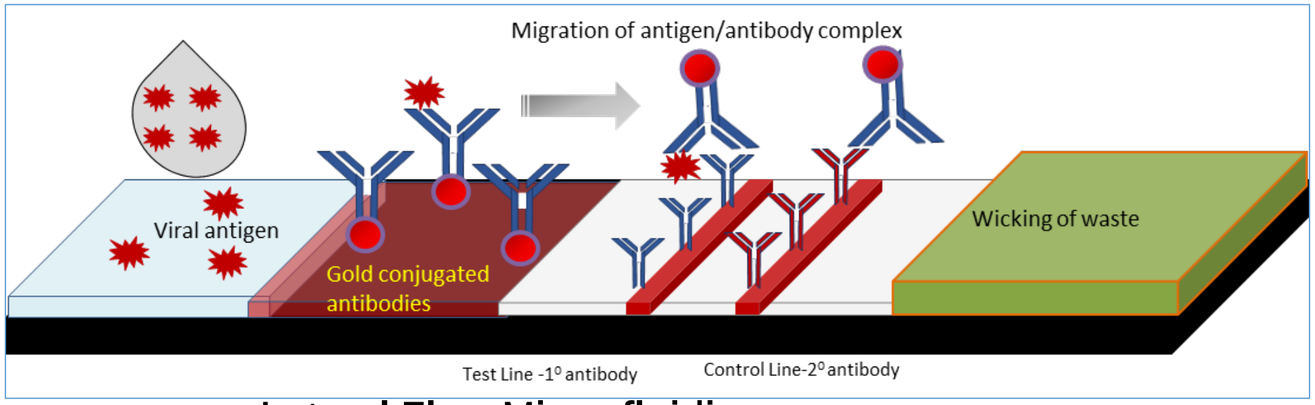
# Samples	# pools	# infected samples (unknown to Algorithm)	# of false negatives	# of false positives
1140	90	12	0	6-13 out of 1140 (depends on the choice of algorithm)

Results on data obtained from the Wyss Lab at Harvard, obtained from a liquid handling robot

Results with different algorithms on real lab data (injected RNA) acquired from NCBS and Harvard.

Dataset	Algorithm	# true pos	# false neg	#false pos
Harvard $24 \times 60, k = 2$	COMP	2	0	1
	COMP-SBL	2	0	1
	COMP-NNOMP	2	0	0
	COMP-NNLASSO	2	0	1
Dataset	**Algorithm**	**# true pos**	**# false neg**	**#false pos**
NCBS-0 $16 \times 40, k = 0$	COMP	0	0	0
	COMP-SBL	0	0	0
	COMP-NNOMP	0	0	0
	COMP-NNLASSO	0	0	0
Dataset	**Algorithm**	**# true pos**	**# false neg**	**#false pos**
NCBS-1 $16 \times 40, k = 1$	COMP	1	0	0
	COMP-SBL	1	0	0
	COMP-NNOMP	1	0	0
	COMP-NNLASSO	1	0	0
Dataset	**Algorithm**	**# true pos**	**# false neg**	**#false pos**
NCBS-2 $16 \times 40, k = 2$	COMP	2	0	0
	COMP-SBL	2	0	0
	COMP-NNOMP	2	0	0
	COMP-NNLASSO	2	0	0
Dataset	**Algorithm**	**# true pos**	**# false neg**	**#false pos**
NCBS-3 $16 \times 40, k = 3$	COMP	3	0	1
	COMP-SBL	2	1	1
	COMP-NNOMP	2	1	0
	COMP-NNLASSO	2	1	1
	COMP-BF	2	1	1
Dataset	**Algorithm**	**# true pos**	**# false neg**	**#false pos**
NCBS-4 $16 \times 40, k = 4$	COMP	4	0	3
	COMP-SBL	3	1	2
	COMP-NNOMP	2	2	2
	COMP-NNLASSO	2	2	3
	COMP-BF	2	2	2

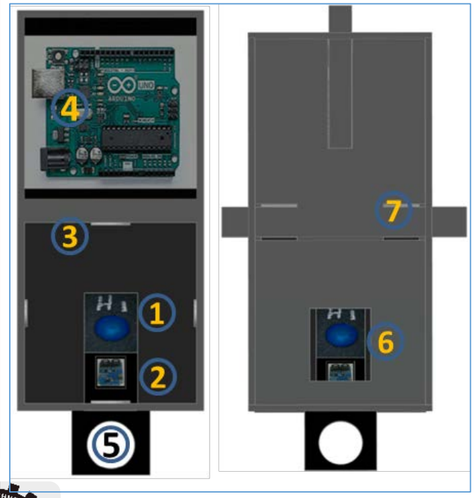
Cyber Physical Point of Care System for Rapid Low-Cost Saliva-based Testing



Lateral Flow Micro-fluidics

Microfluidics for COVID-19 Diagnostics

- Reverse Transcription Loop-Mediated Isothermal Amplification (RT-Lamp) followed by lateral flow based Paper-Microfluidics can be implemented in a single miniaturized portable platform
- Colorimetric quantitative detection is possible using smartphone technology along with the portable device



Microfluidic Device

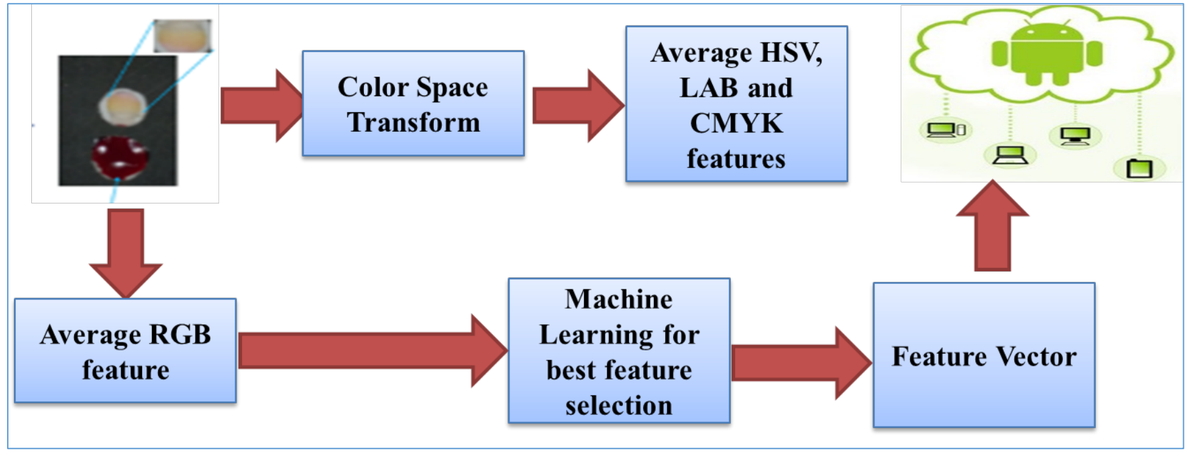
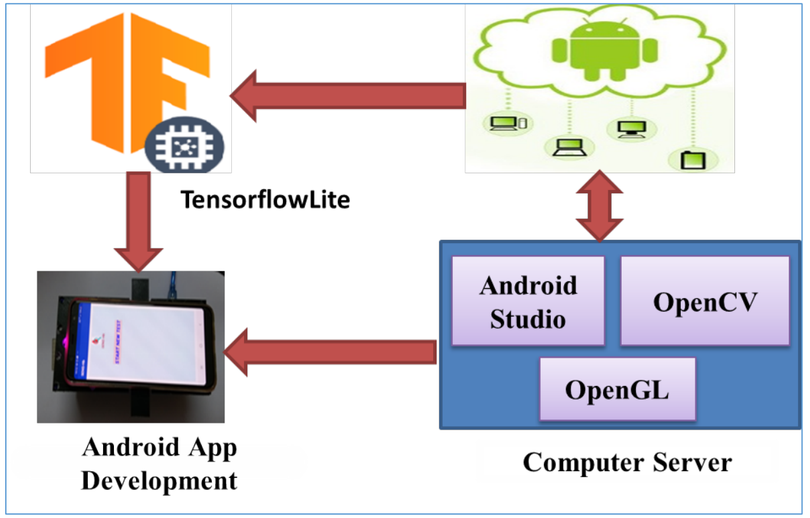


Image Analytics



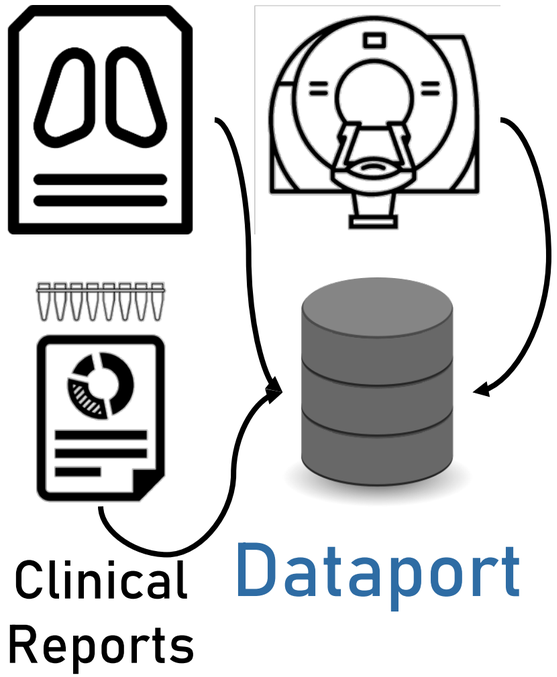
Smart Phone Integration

Prof Suman Chakrabarti et al, IIT Kharagpur

Collaborative Platforms to Develop Solutions

Contribute

Annotations Cases

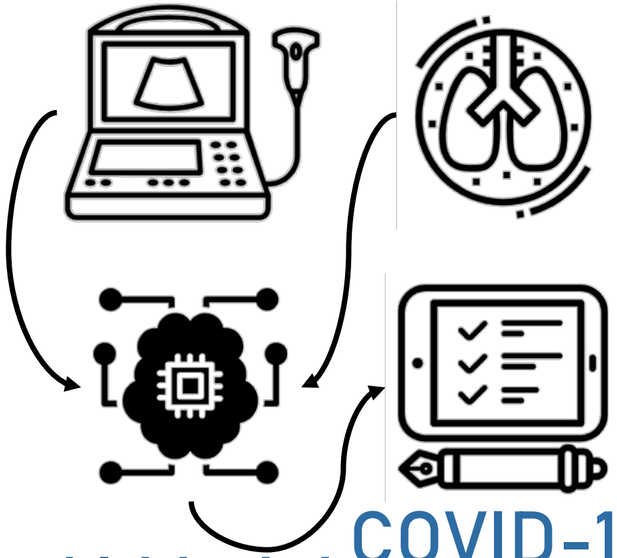


Clinical Reports

Dataport

Build

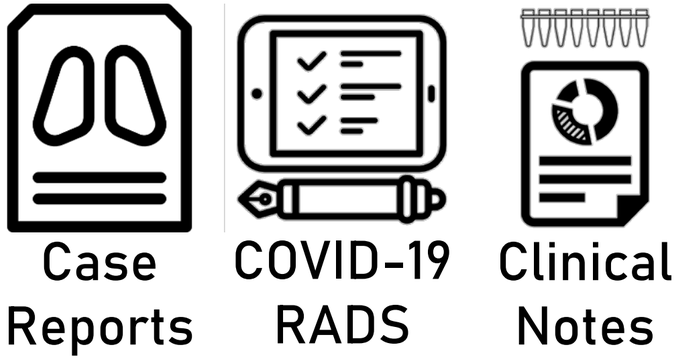
Ultrasound X-Ray / CT



AI Model

COVID-19 RADS

Educate

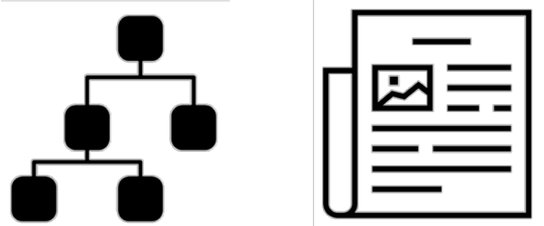


Case Reports

COVID-19 RADS

Clinical Notes

Share



AI Models

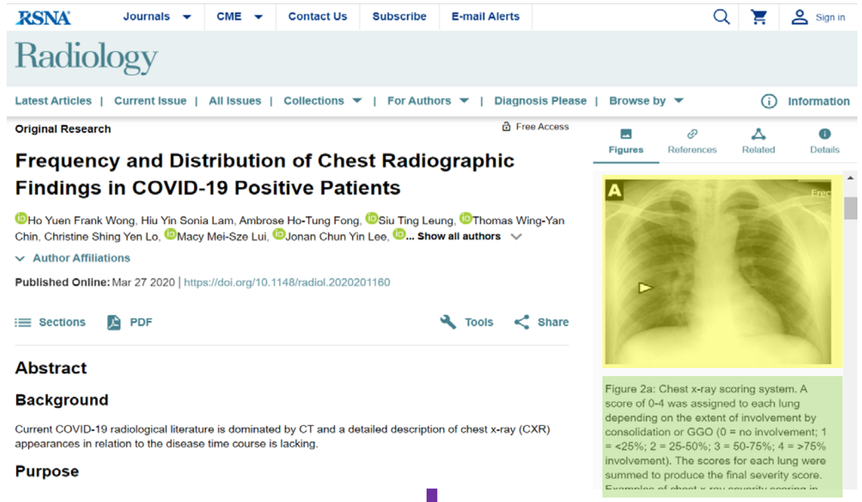
Whitepapers

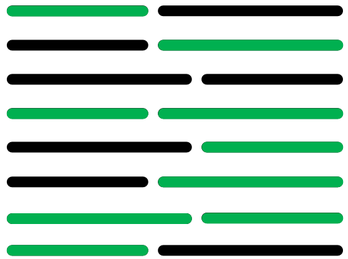
Dr Debdoot Sheet et al, IIT Kharagpur

Building COVID-19 Radiology Reporting and Data Standards (RADS)

Dr Debdoot Sheet et al, IIT Kharagpur

Web Crawler





Saliency analysis, Content spotting

Tokenization and Parsing

RSNA®
ACR®
AMERICAN COLLEGE OF RADIOLOGY

Common Data Elements (CDE) for Radiology

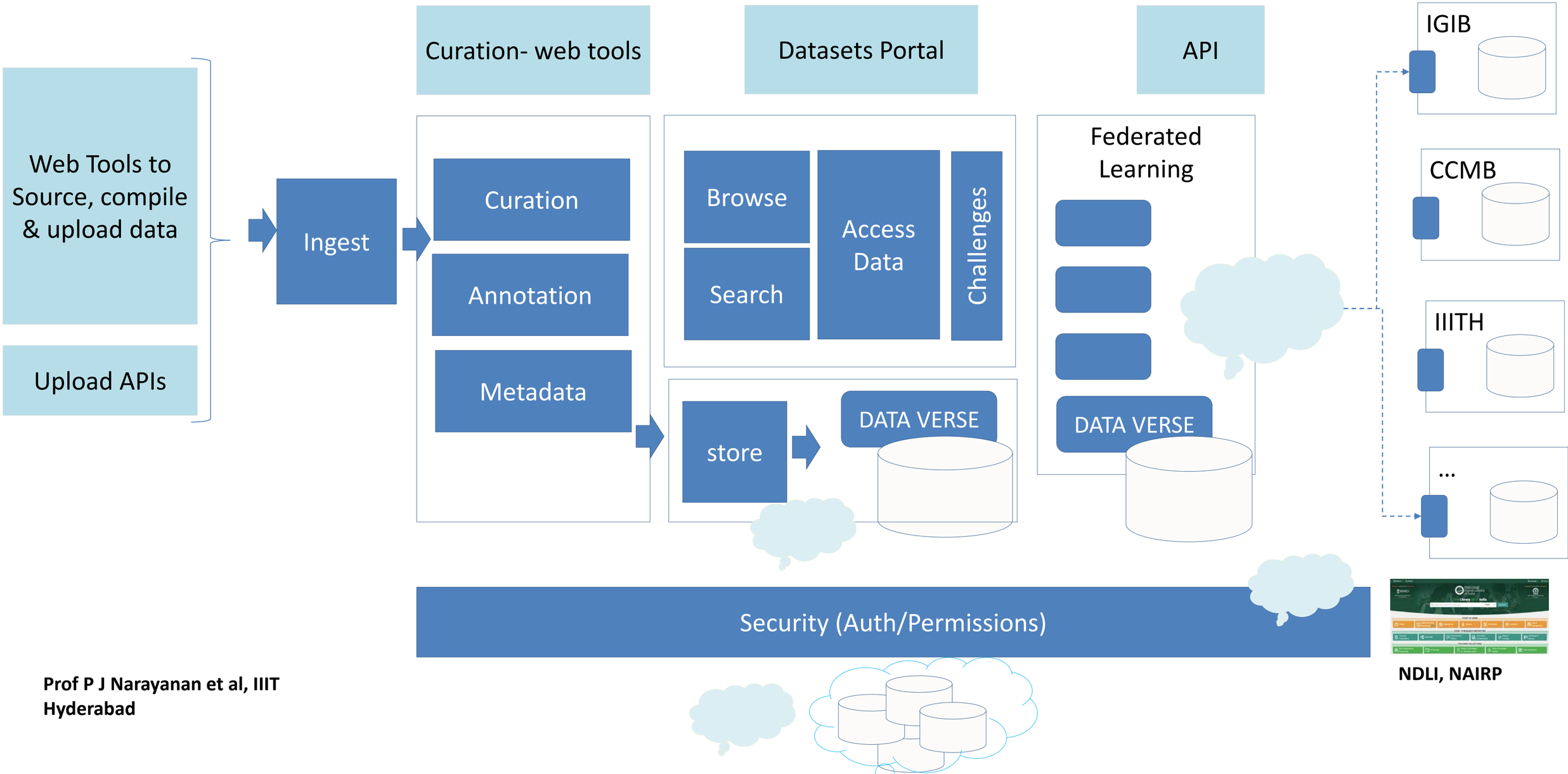
COVID-19 RADS v0.1

Vote Aggregation

COVID-19 RADS v0.2

IIT KHARAGPUR

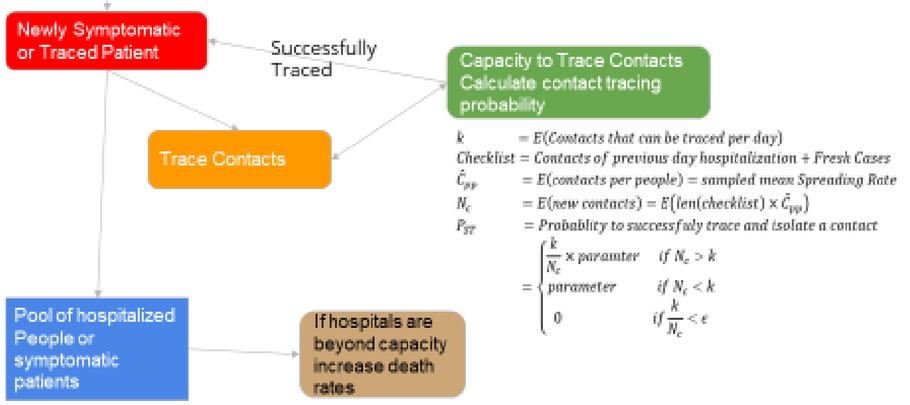
Data Architecture for COVID Repository



Prof P J Narayanan et al, IIIT Hyderabad

AI Powered Scenario Analysis

Contact Tracing



k = E(Contacts that can be traced per day)

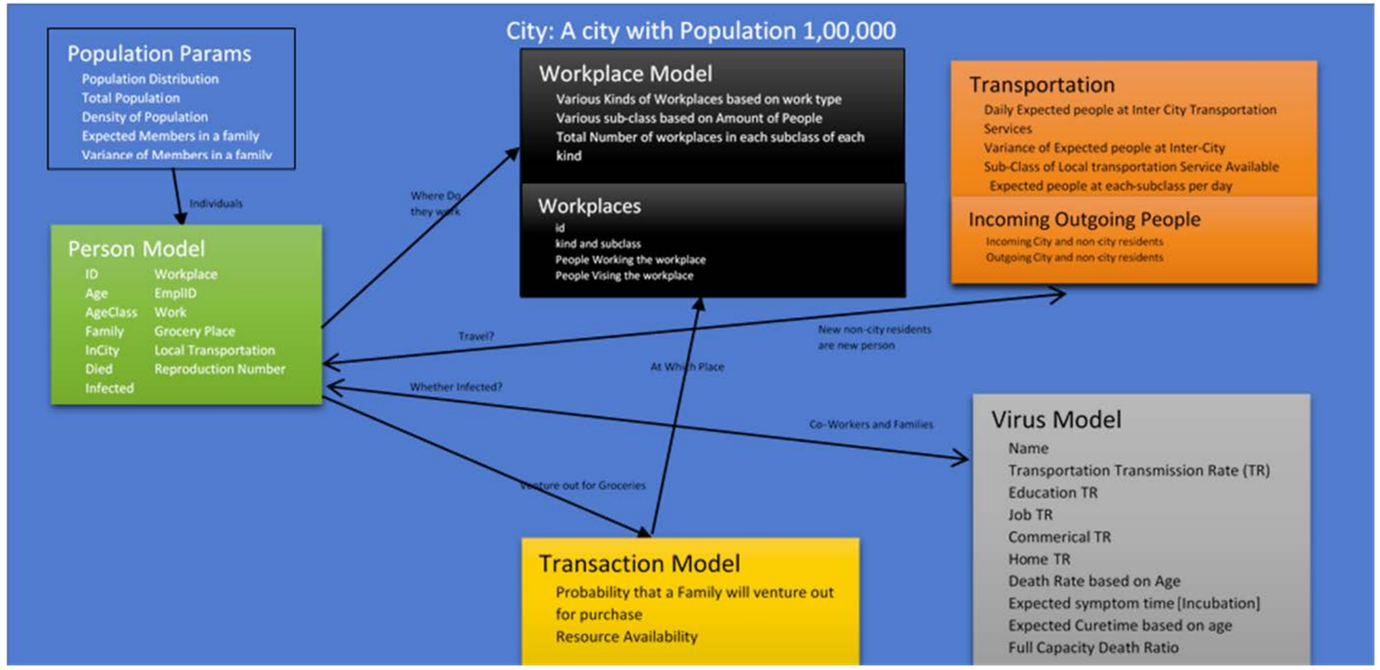
$Checklist$ = Contacts of previous day hospitalization + Fresh Cases

$\bar{C}_{pp}$ = E(contacts per people) = sampled mean Spreading Rate

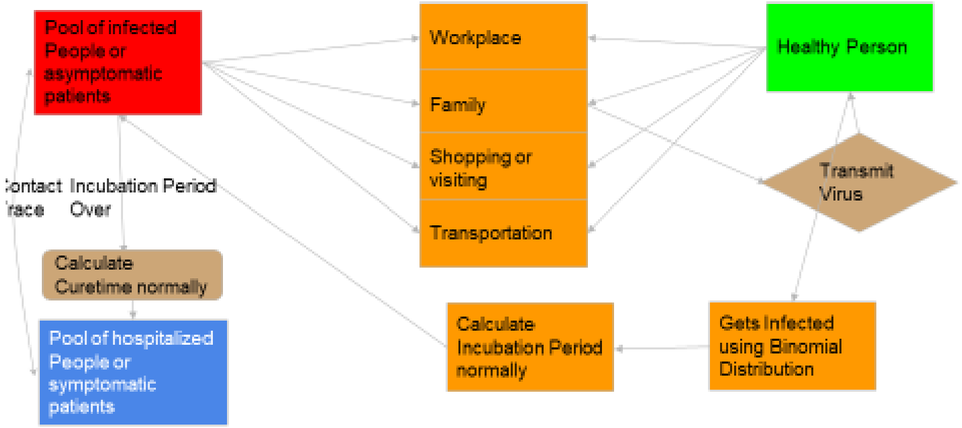
N_c = E(new contacts) = $E[len(checklist) \times \bar{C}_{pp}]$

P_{ST} = Probablity to successfuly trace and isolate a contact

$$= \begin{cases} \frac{k}{N_c} \times paramter & if\ N_c > k \\ parameter & if\ N_c < k \\ 0 & if\ \frac{k}{N_c} < \epsilon \end{cases}$$

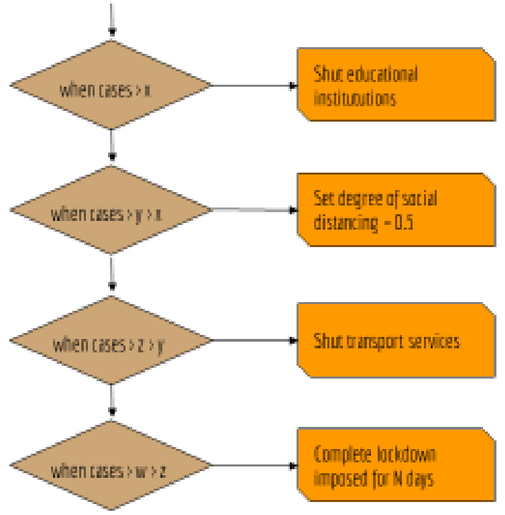


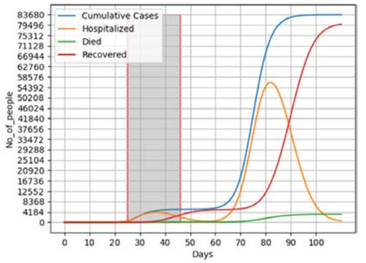
Virus Model daily transmissions

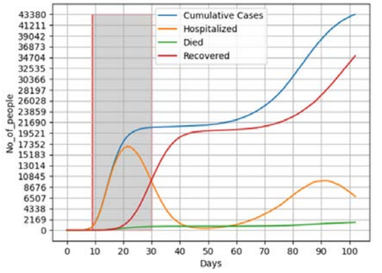


Lockdown Model

- Lockdowns are imposed as the number of hospitalized cases increase (see Simulation)
- Lockdown model can be a complex or simple decision tree which can be customizable. An example is given on the right
- **Social distancing of degree x** – represents that the transmission rates have fallen by ratio of 1/x.
- **Transportation Locked** – people are not allowed to cross borders
- **Education Locked** – all schools and colleges shut.
- **Complete Lockdown** – Degree of social distancing set to 2, all jobs locked in addition to education and transportation lockdowns.



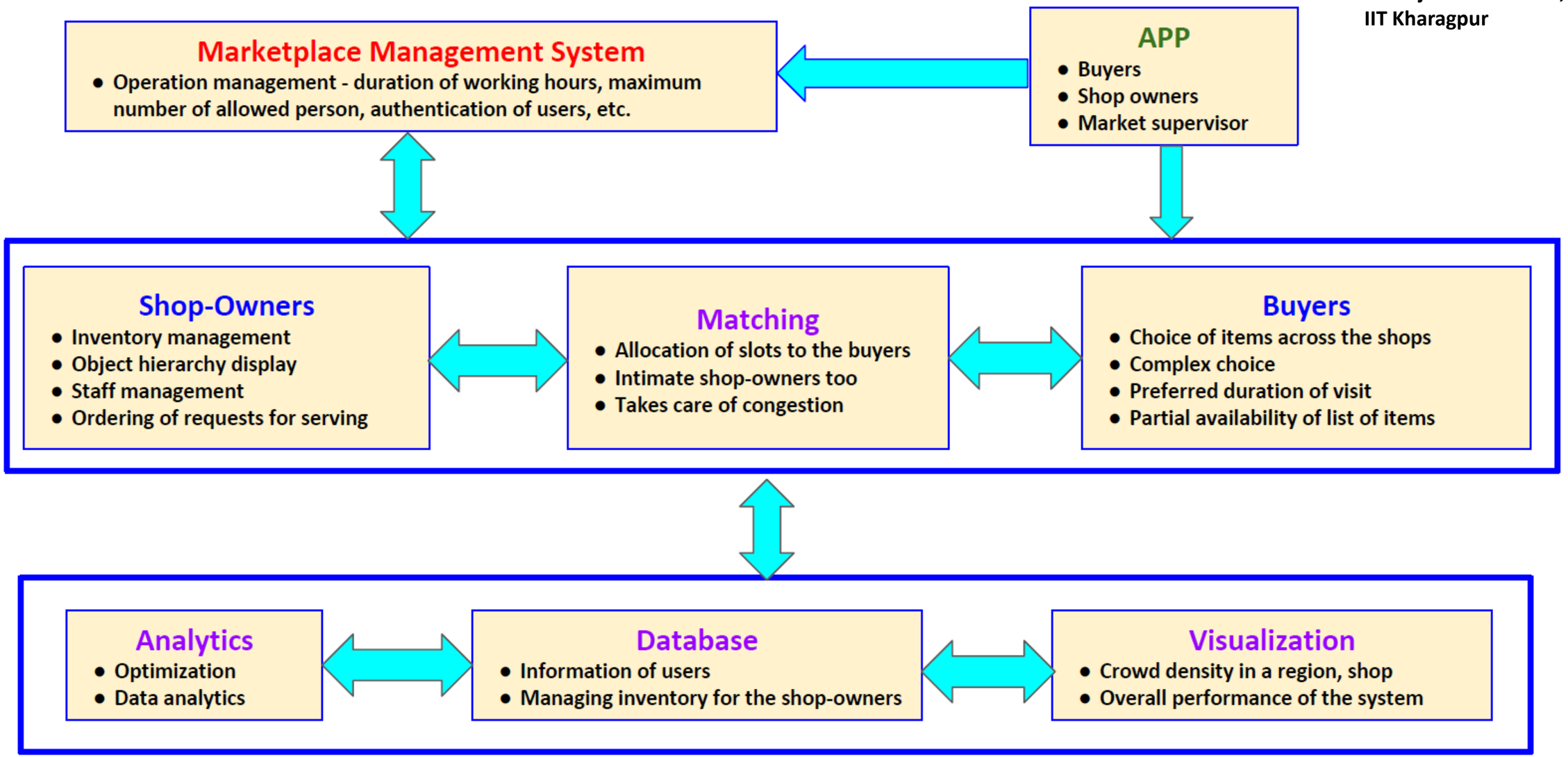




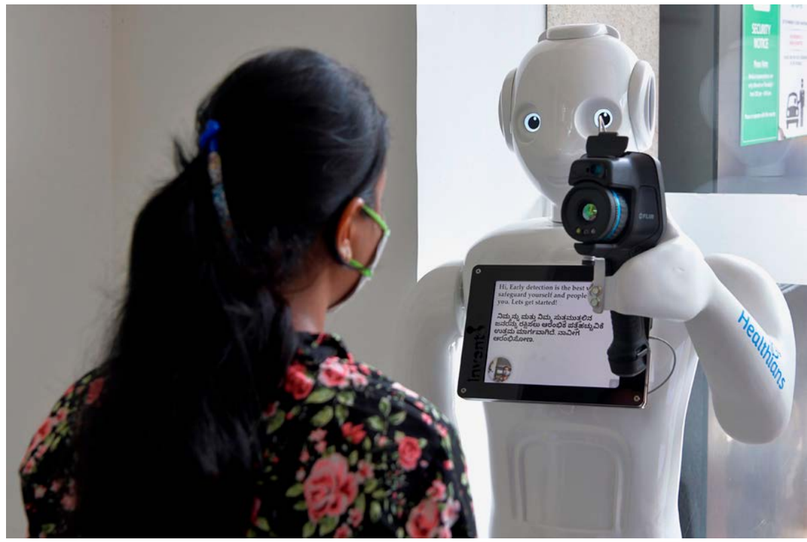
Dr Adway Mitra, et al, IIT Kharagpur

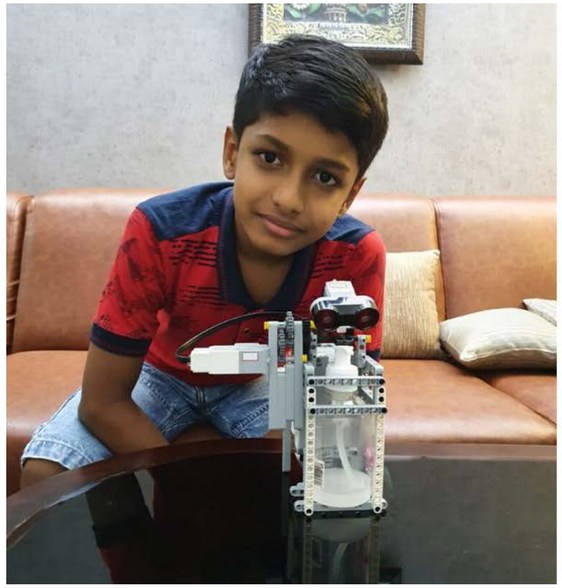
Management of Physical Places (Markets, Hospitals, etc)

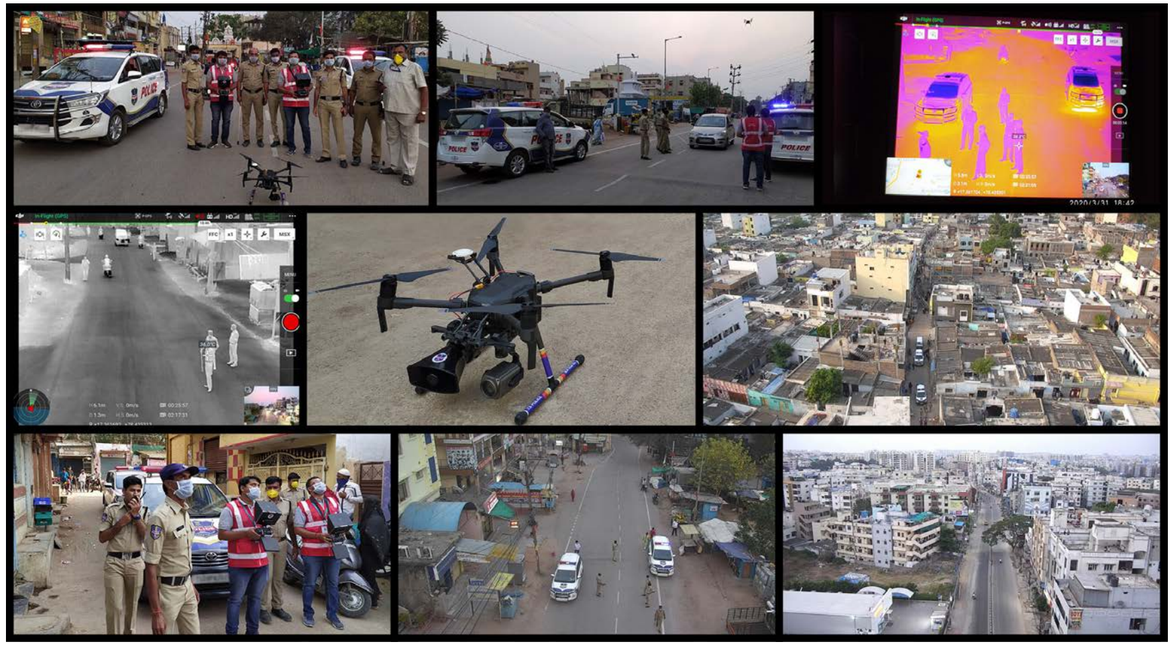
Dr Arijit Mondal et al,
IIT Kharagpur



Robotics for COVID

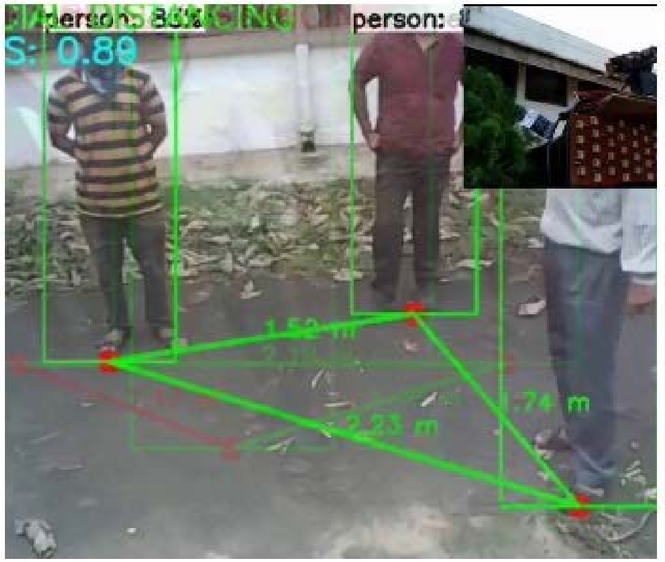


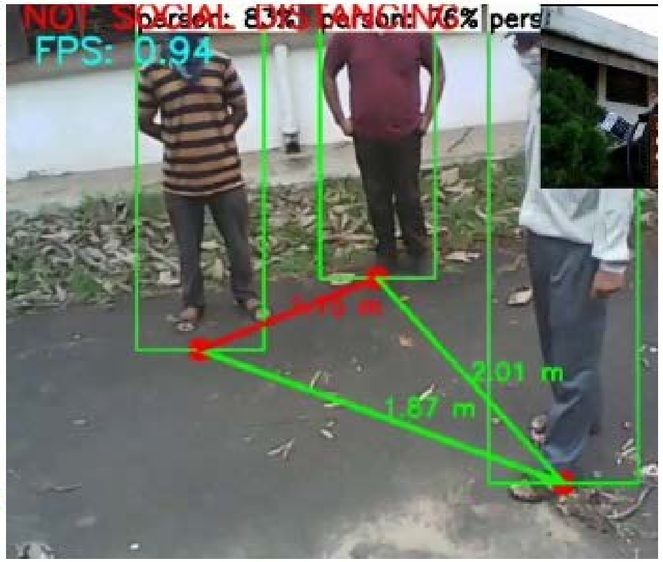


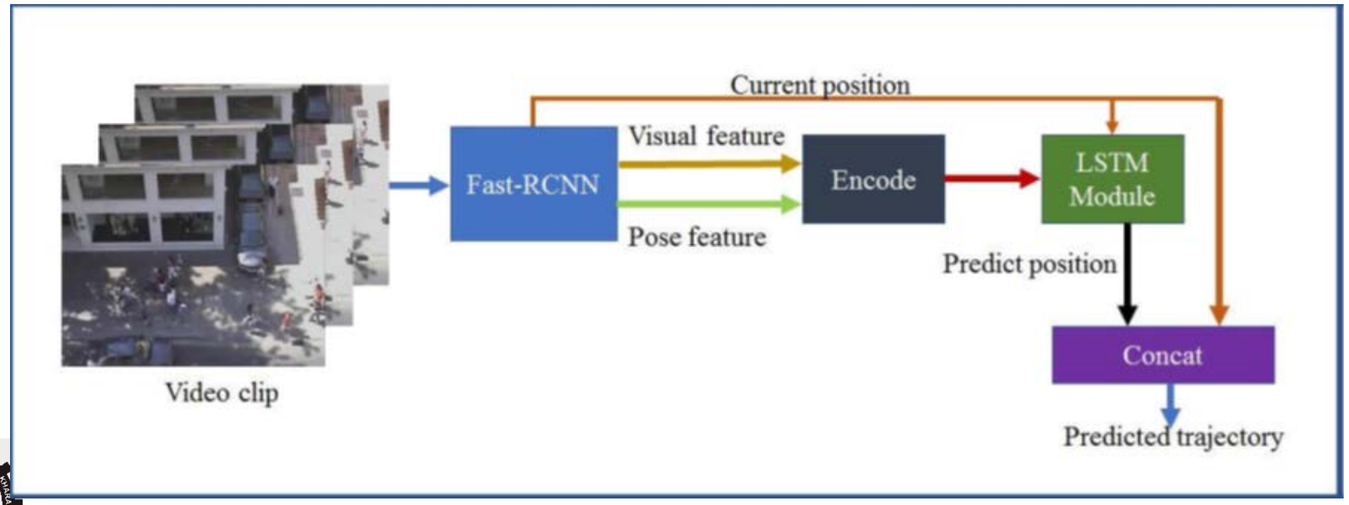


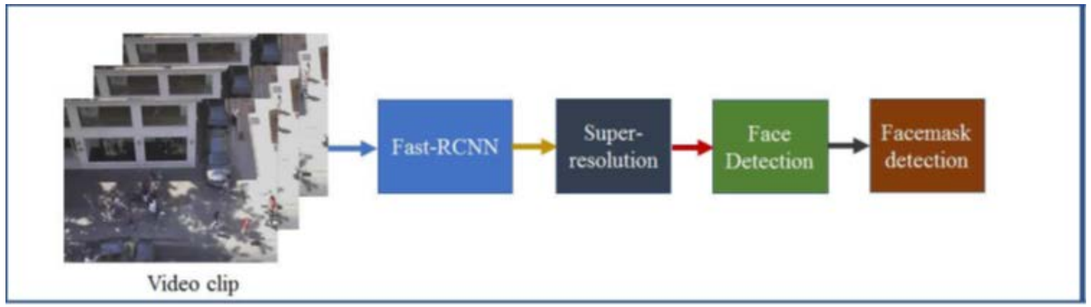
Social Distancing

Prof Debasish Chakravarty, et al, IIT Kharagpur





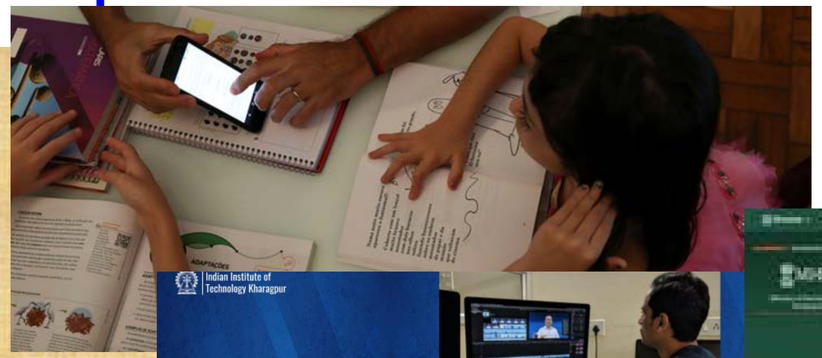




Dr Saumik Bhattacharyya, IIT Kharagpur

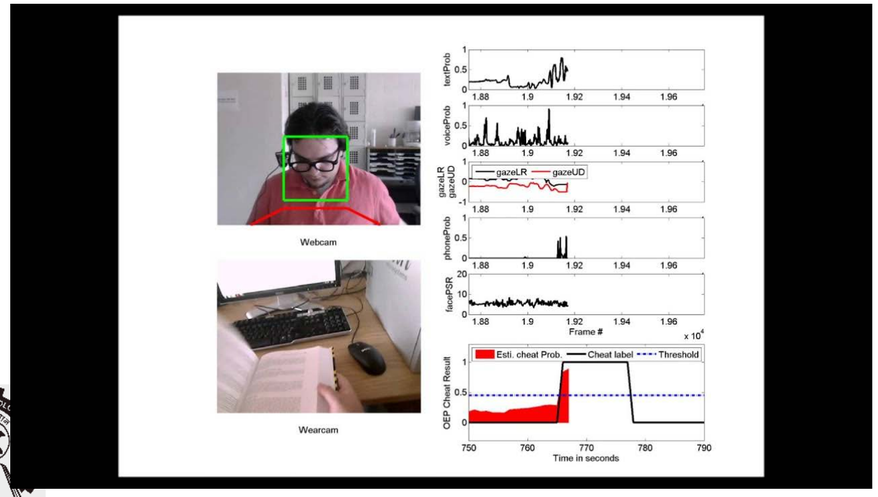
E-Morphosis of Education

- Pre COVID
  - Little digital adoption
  - Watching Videos
- During COVID
  - All mediums have been activated
    - Live Classes
    - Recorded Lectures
    - Tests
    - Practice etc
  - The trainings of teachers have all been done online



FREE ONLINE EDUCATION
swayam
शिक्षित भारत, उन्नत भारत

National Digital Library of India



- Interactive LIVE Classes
- AI-powered Video Archives
- Personalized Learning Plan
- Online Practice Labs
- Group Labs and Hackathons
- One-to-one Mentor Support
- Multi-device Access
- Interactive Forums
- And more...

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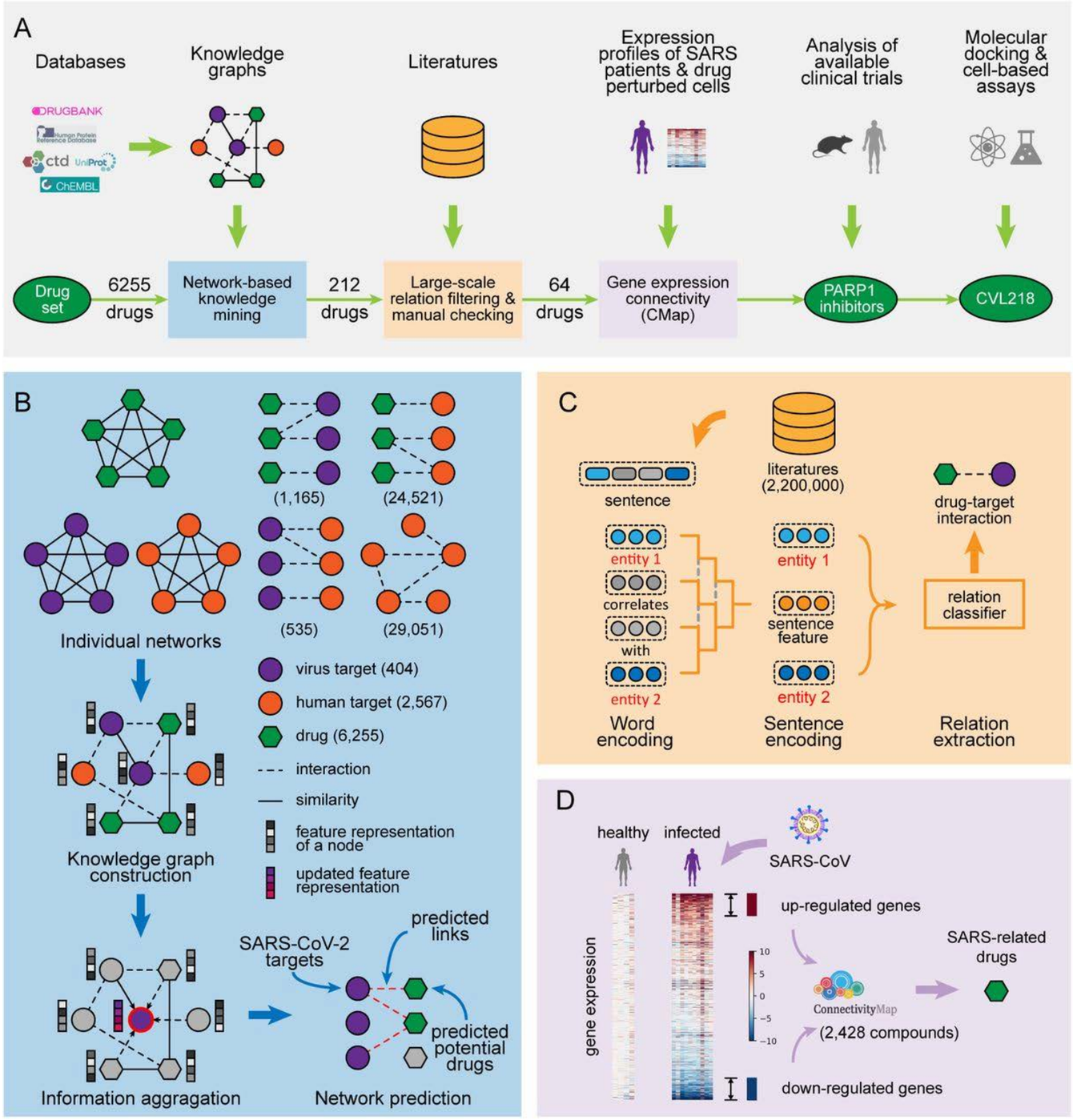
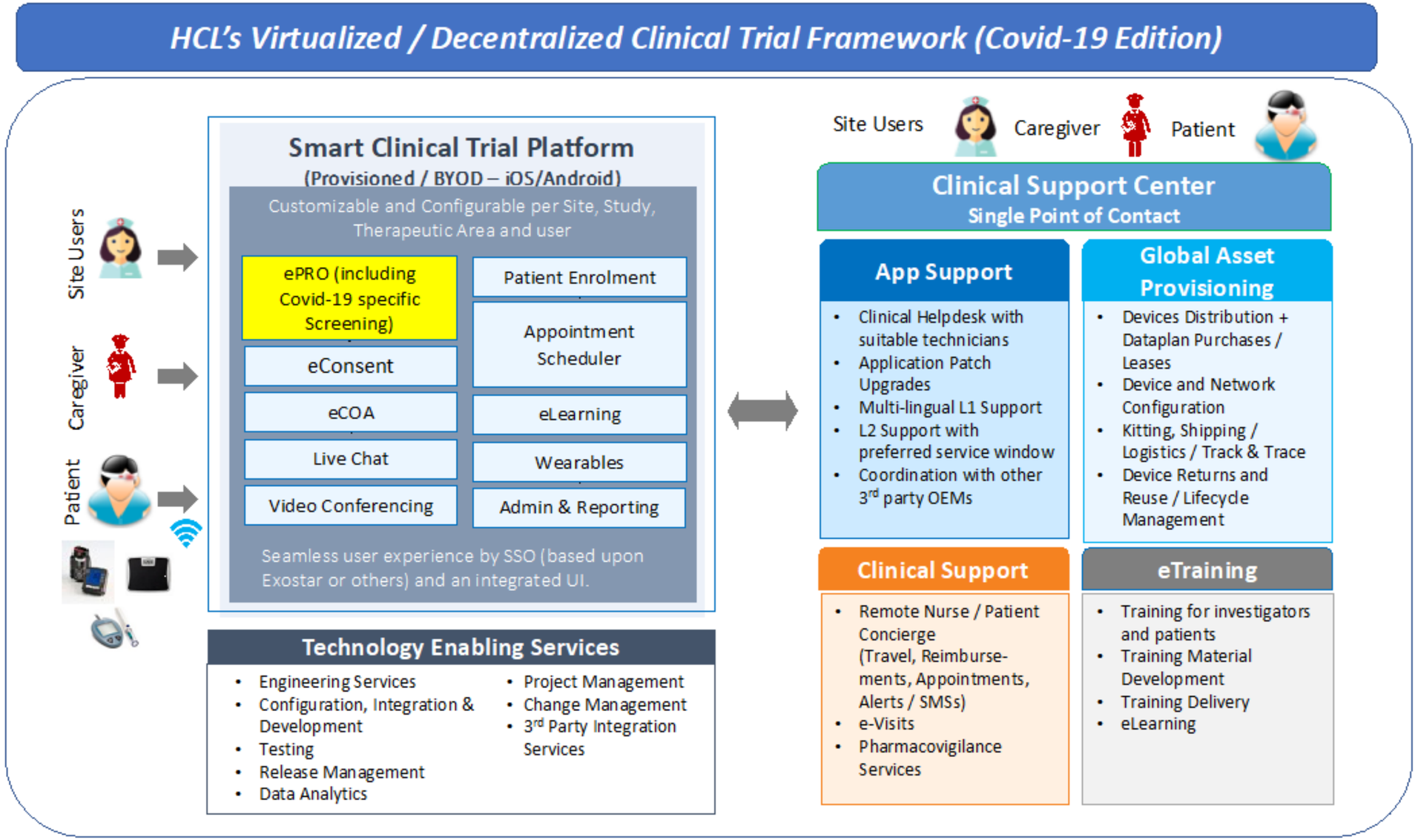
Drug Repurposing



Virtualized Clinical Trials / Home Management



EFFECTIVE USE OF AI / ML CAN LEAD TO SOME OF THE MOST HEARTENING OUTCOMES IN COVID-19

BUT WE STILL HAVE A LONG WAY TO GO

Thank you for Listening