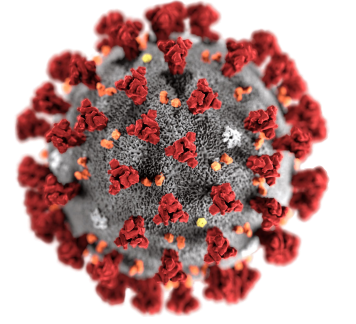




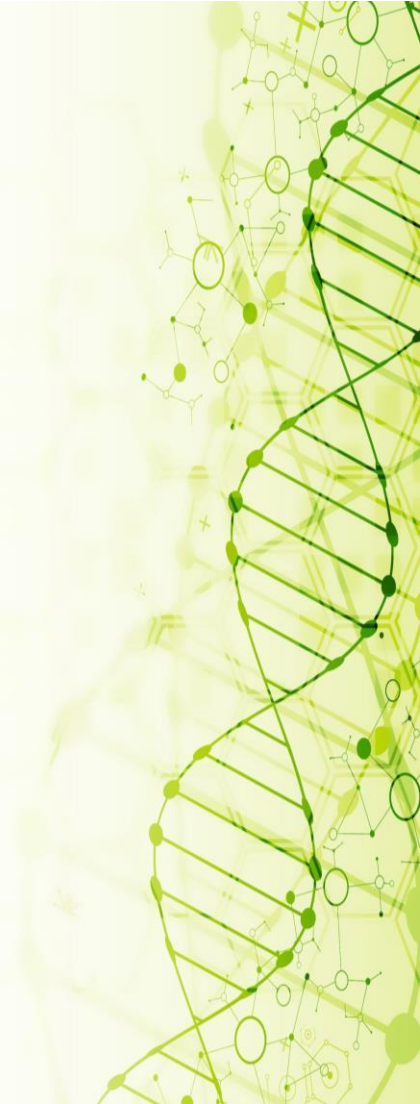
Applications of Machine Learning to fight COVID-19

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Dept. of IT, NSUT, Delhi

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Disease

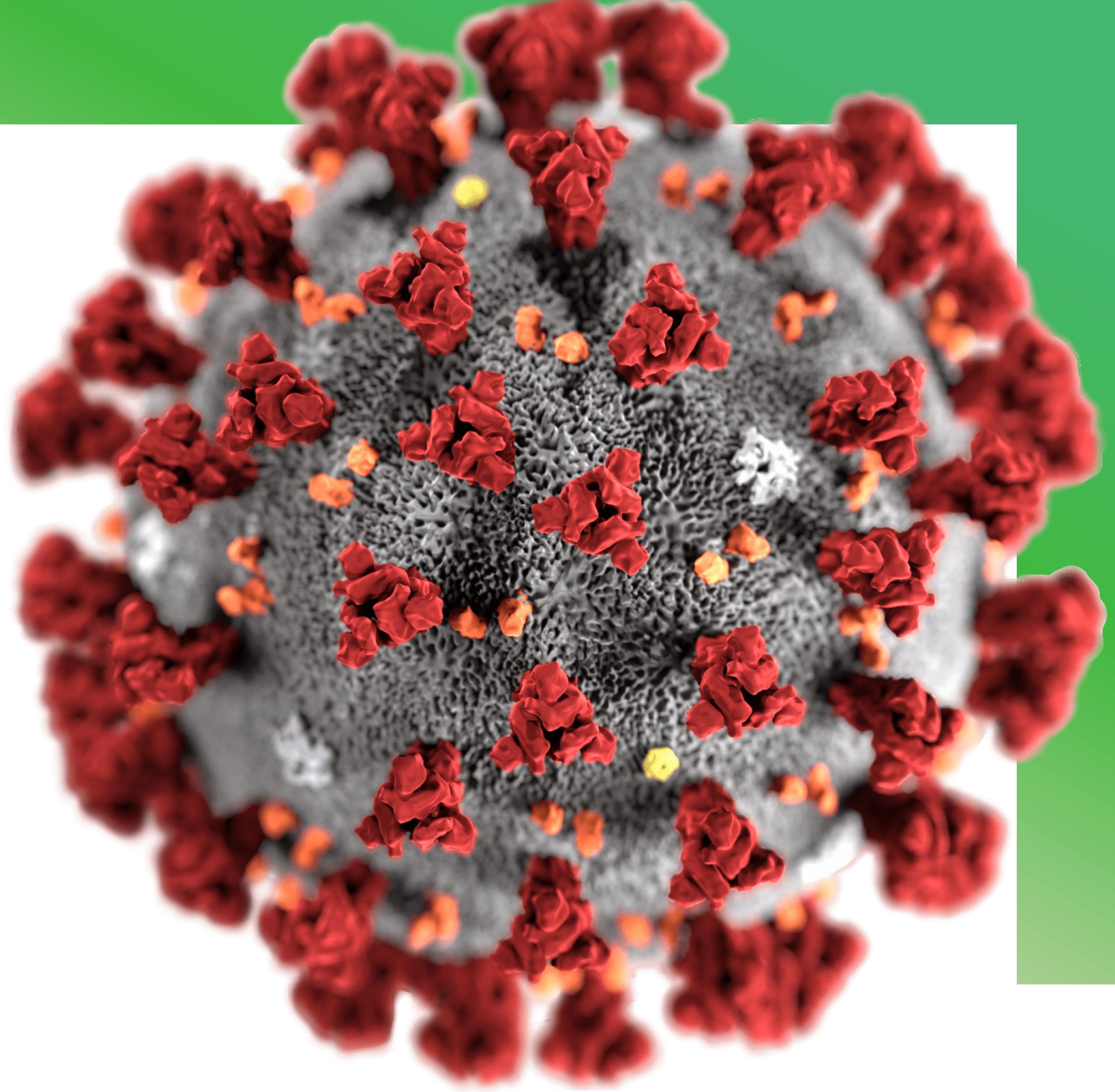
COVID-19

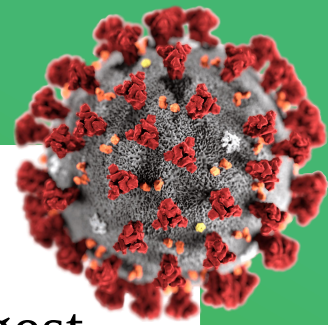
SARS-CoV-2

2019-nCoV

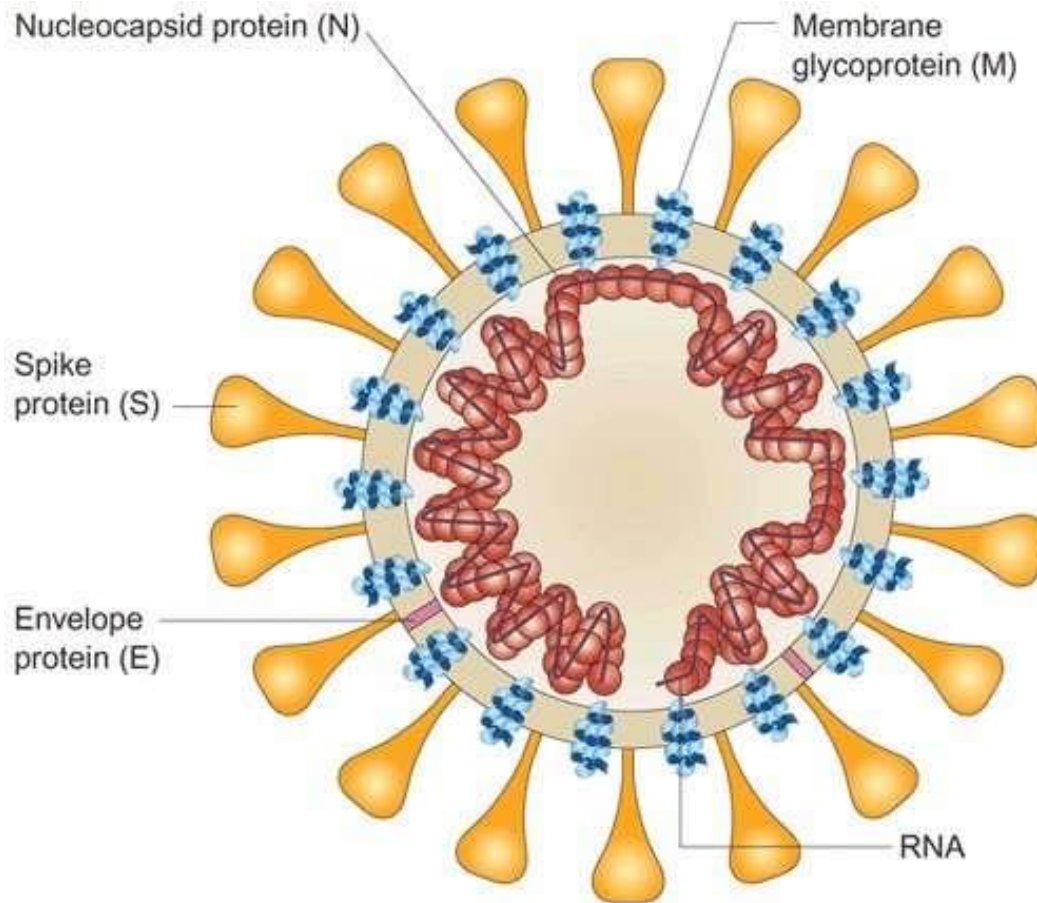
HCoV-19

Virus Name





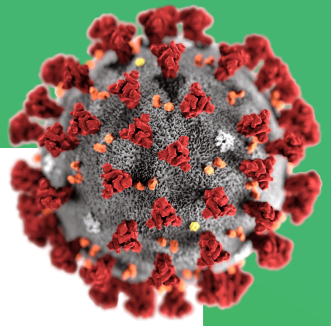
Coronavirus Structure



- Medium-sized virus size, but largest mRNA genome
- Enveloped +ve stranded RNA
- mRNA encased in nucleocapsid
- Lipid Bilayer – Soap works to disrupt this!

Corona = Crowns for Spikes

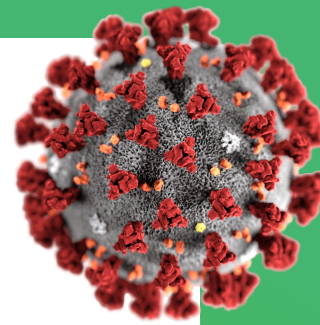
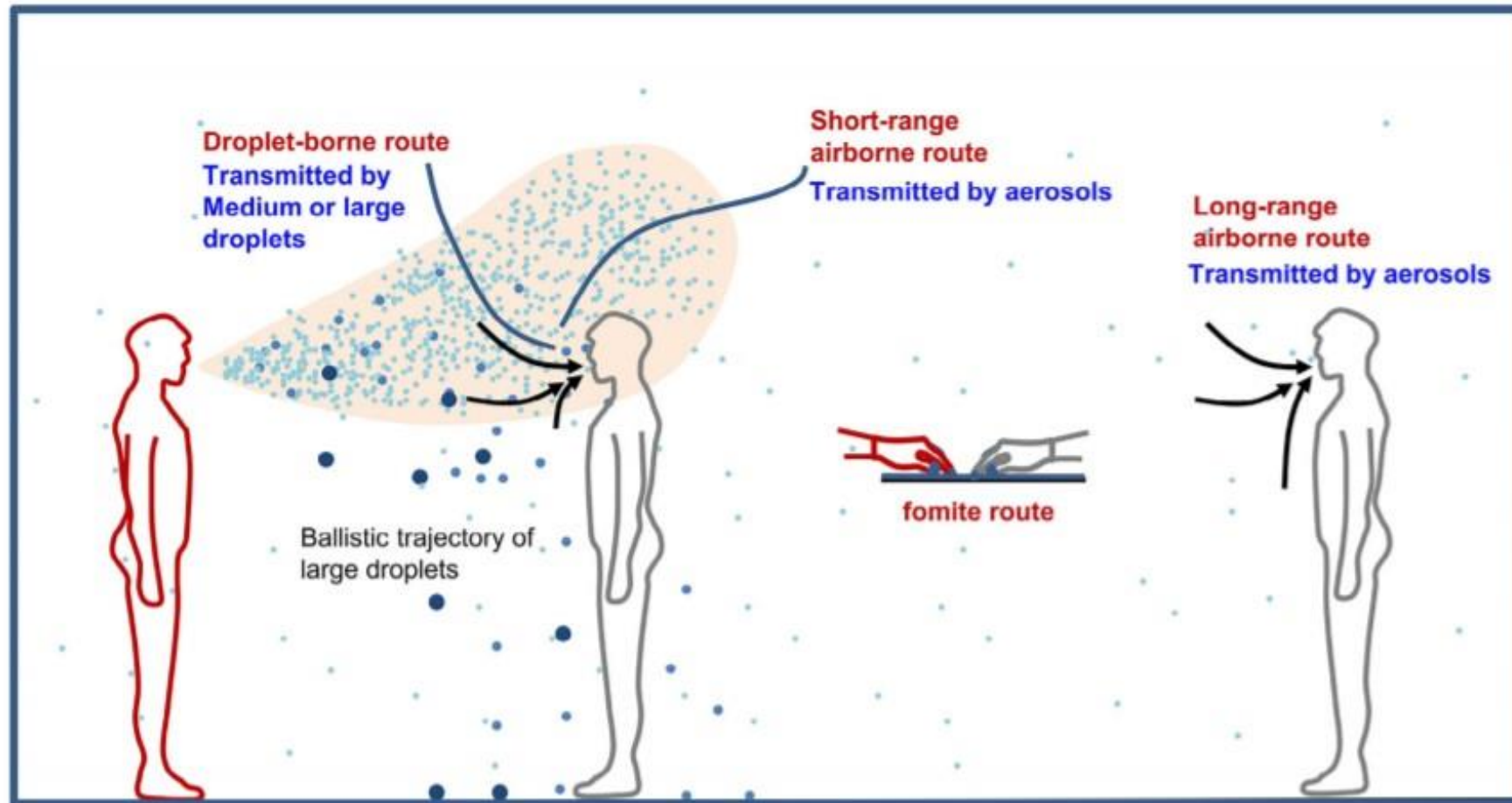
- Glycoprotein Spike (S) Peptomer
- Spikes allow it to attach to human cell receptors in upper or lower airway



SARS-Cov-2 Transmission

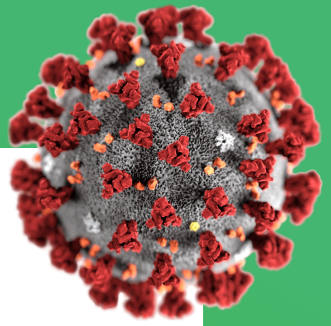
- + Respiratory droplets (large - 3 ft, medium - 6 ft)
- + Hand-to-mucus-membrane contact – sticks to skin easily!
T-zone: eyes, nose, mouth vulnerable
- + Viable for 3 days on solids (plastics, porcelain, steel); ~24 hours cardboard, dependent also on temperature/humidity; 3 hours if aerosolized
- + Airborne – likely not airborne with cough? But certainly possible with intubation, non-invasive positive pressure ventilation, high flow O₂, nebulizer, suctioning
- + ?Fecal/oral? – viral shedding present in stool and diarrhea is common

<https://www.medrxiv.org/content/10.1101/2020.03.09.20033217v1.full.pdf>



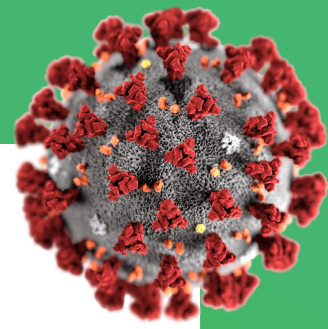
- Large droplets ($>100\ \mu\text{m}$) : Fast deposition due to the domination of gravitational force
- Medium droplets between 5 and $100\ \mu\text{m}$
- Small droplets or droplet nuclei, or aerosols ($< 5\ \mu\text{m}$): Responsible for airborne transmission

Fig 4. Illustration of different transmission routes. Small droplets ($<5\ \mu\text{m}$), sometimes called aerosols, are responsible for the short-range airborne route, long-range airborne route, and indirect contact route; large droplets are responsible for the direct spray route and indirect contact route.



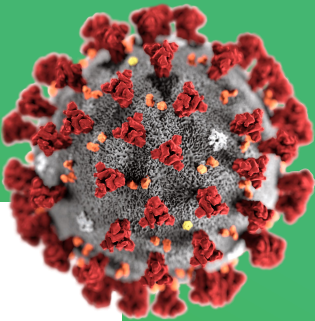
Seasonality and Mutation Rate

- + We don't know.
- + Some CoV are seasonal in northern hemisphere; MERS is not.
- + High disease burden and outbreaks obscure seasonality.
- + Typical viral mutation rate; see NextStrain for real time gene sequencing: <https://nextstrain.org/>
Major strain development: **L type** (more virulent) and **S type** (wild type/apparent first strain). Lethality difference unclear.
- + Normally viruses become more benign over time. However, delayed symptom onset, delayed time to death, poor access to diagnosis with isolation, contact tracing and quarantine makes deadly strains persist.



Symptoms and Disease Course

- + Week 1: Fever (77-98%) (intermittent or persistent), Fatigue/Malaise (11-52%), Dry cough (46-82%), dyspnea (3-31%);
Less common: Sputum (33%), Myalgia (15%), Headache (13%), Sore throat (14%), Diarrhea (4%), Nausea/Vomiting (5%), Nasal congestion (4%), Hemoptysis (1%)
- + Week 2 (~ day 6-9 of symptoms): ~ 15-20% develop severe dyspnea due to viral pneumonia
Hospitalization, supportive care, oxygen
- + Week 2-3: Of hospitalized patients, 1/3 ultimately need ICU care, with up to half needing intubation (i.e. ~5% of total diagnosed cases need ICU)
Can rapidly decline (over 12-24 hrs) from mild hypoxia to frank ARDS
Cytokine Storm, Multi-organ failure
Late stage sudden cardiomyopathy/viral myocarditis, cardiac shock

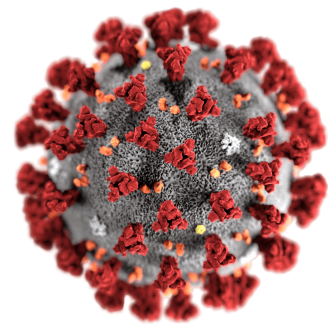


COVID-19 Variants

GREEK ALPHABET

By Ben Crowder • bencrowder.net • Last modified 2 May 2012

Αα ALPHA [a] ἄλφα	Ββ BETA [b] βῆτα	Γγ GAMMA [g] γάμμα	Δδ DELTA [d] δέλτα	Εε EPSILON [e] ἒ ψιλόν	Ζζ ZETA [dz] ζῆτα
Ηη ETA [eː] ἦτα	Θθ THETA [tʰ] θῆτα	Ιι IOTA [i] ἰῶτα	Κκ KAPPA [k] κάππα	Λλ LAMBDA [l] λάμβδα	Μμ MU [m] μῦ
Νν NU [n] νῦ	Ξξ XI [ks] ξεί	Oο OMICRON [o] ὀ μικρόν	Ππ PI [p] πεῖ	Ρρ RHO [r] ῥῶ	Σσς SIGMA [s] σίγμα
Ττ TAU [t] ταῦ	Υυ UPSILON [u] ῥ ψιλόν	Φφ PHI [pʰ] φεῖ	Χχ CHI [kʰ] χεῖ	Ψψ PSI [ps] ψεῖ	Ωω OMEGA [ɔː] ὦ μέγα

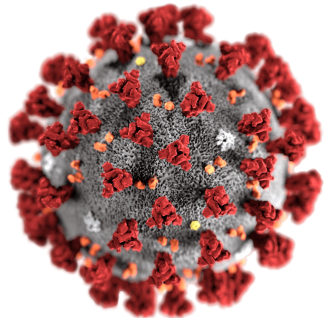


COVID-19

- + An infectious disease caused by SARS-CoV-2 virus.
- + Impacts physical health from mild respiratory illness to organ failures.
- + No cure, Prevention is the best strategy.
- + Prevention strategies included isolation, affecting the psychological well-being of the individuals.



Pandemic



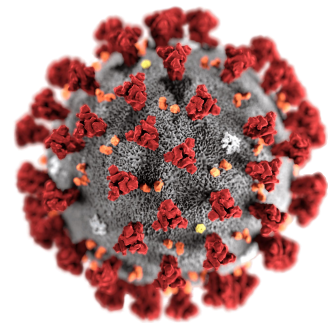
Coronavirus (COVID-19) started in China in December 2019.

As of November 2021, over 2.6 billion cases have been reported around the world, with a mortality rate of 2% of the total closed cases.

This rapid expansion acts as a serious threat to the public health and economy worldwide.

The large upsurge in infection rate, and unavailability of resources has affected the healthcare department brutally.

To reduce the load, researchers developed predictive analytic tools to identify the exposed persons, and the severity of the disease in a patient using machine learning.

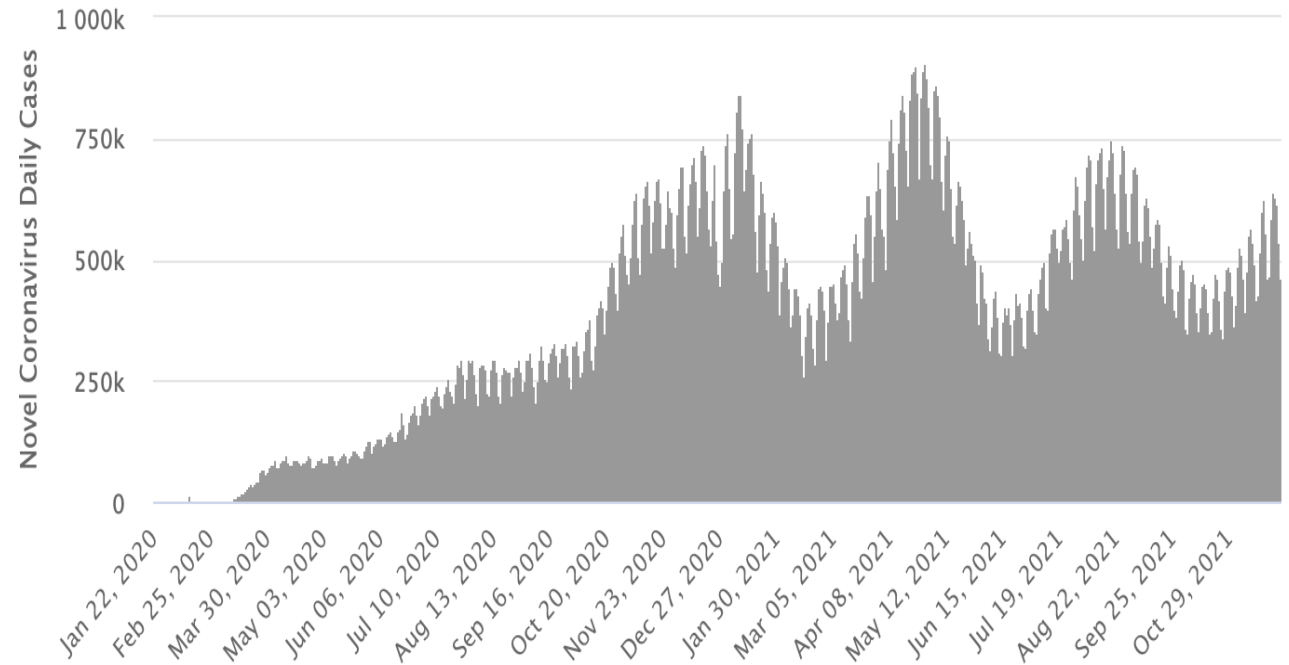


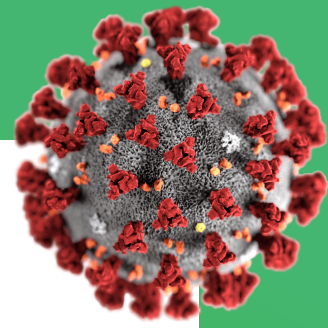
COVID-19 Worldwide

- + Total Cases: **262190844**
- + Total Deaths: **5221803**
- + Total Active Cases: **20235818**
- + Total Recovered: **23673323**

Daily New Cases

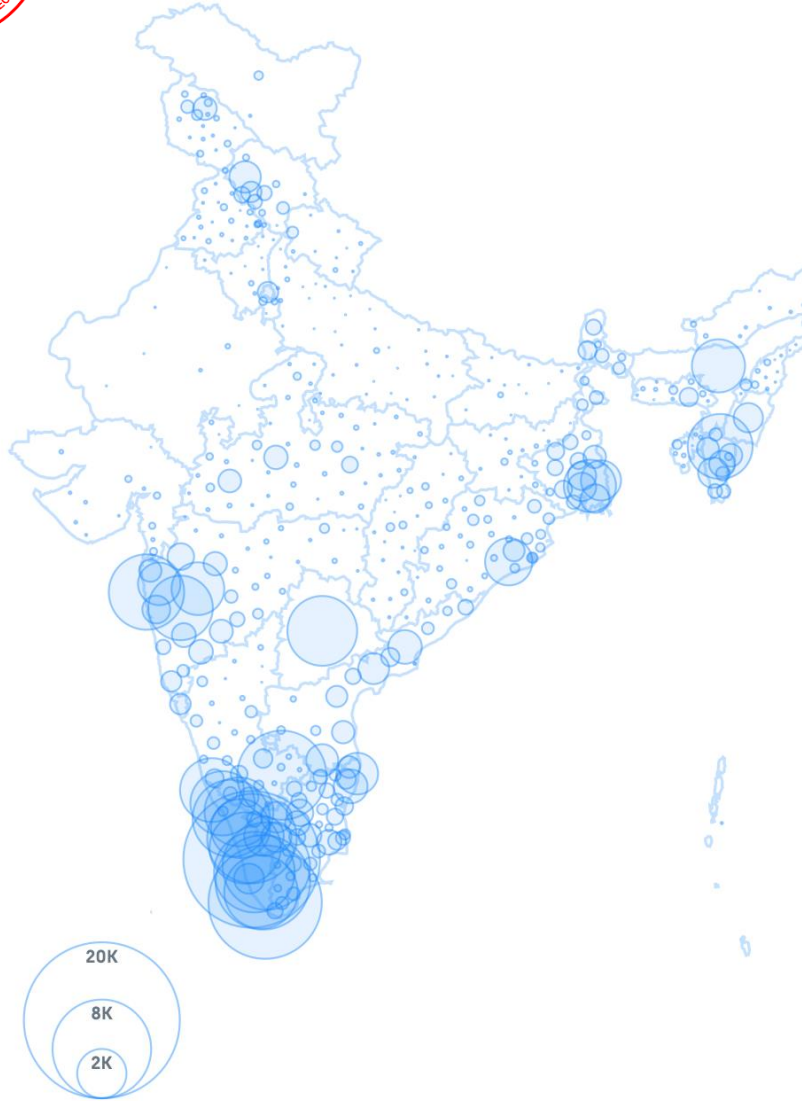
Cases per Day
Data as of 0:00 GMT+0

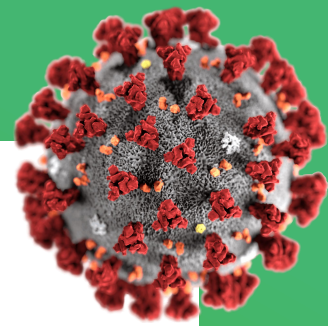




COVID-19 India

- + Total Cases: **34583597**
- + Total Deaths: **468790**
- + Total Active Cases: **106624**
- + Total Recovered: **34008183**





Adverse Effects of COVID-19

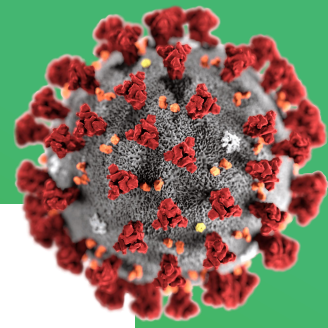
Physical Health

Mental health

Economy

Livelihood

Education



Machine Learning

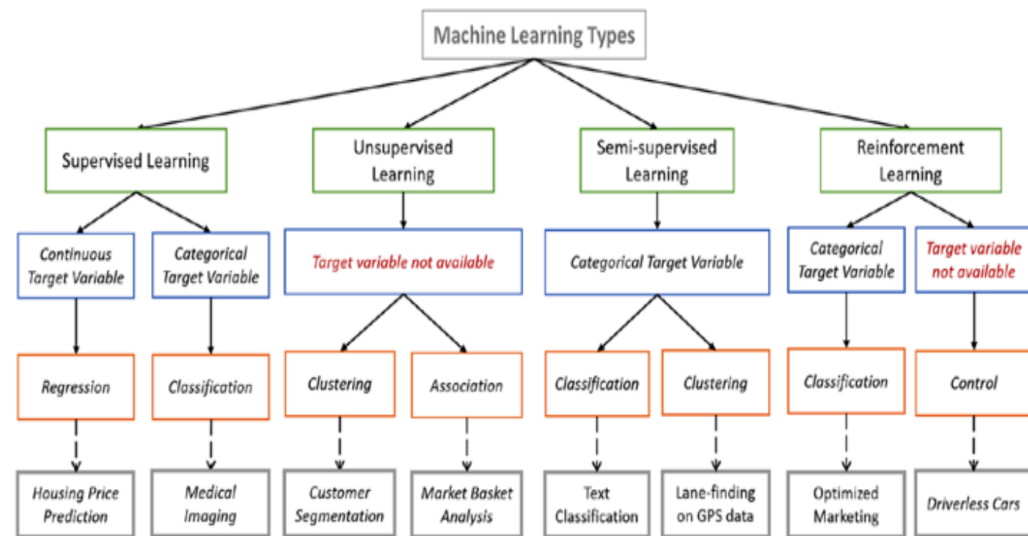
- + A system that improves performance over experience.
- + Involves algorithms and data that automates decision making.
- + Types of learning:

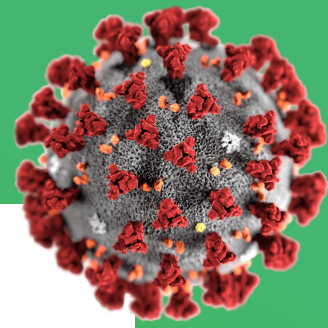
Supervised

Unsupervised

Semi-supervised

Reinforcement Learning





Problems solved well by ML

Recognizing patterns:

- Facial identities or facial expressions
- Handwritten or spoken words – Medical images

Generating patterns:

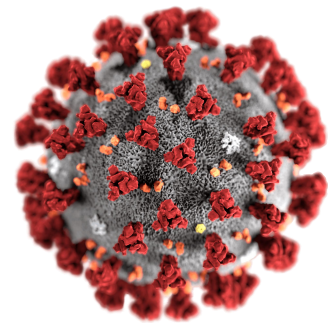
- Generating images or motion sequences

Recognizing anomalies:

- Unusual credit card transactions
- Unusual patterns of sensor readings in a nuclear power plant

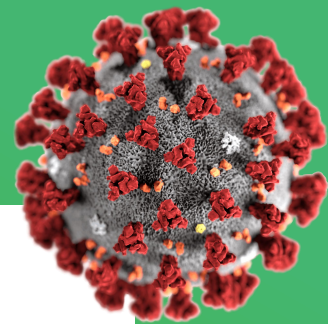
Prediction:

- Future stock prices or currency exchange rates



ML Application Areas

- + Web search
- + Computational biology
- + Finance
- + E-commerce
- + Space exploration
- + Robotics
- + Information extraction
- + Social networks
- + Debugging software
- + Healthcare



Application of ML in fight to COVID-19

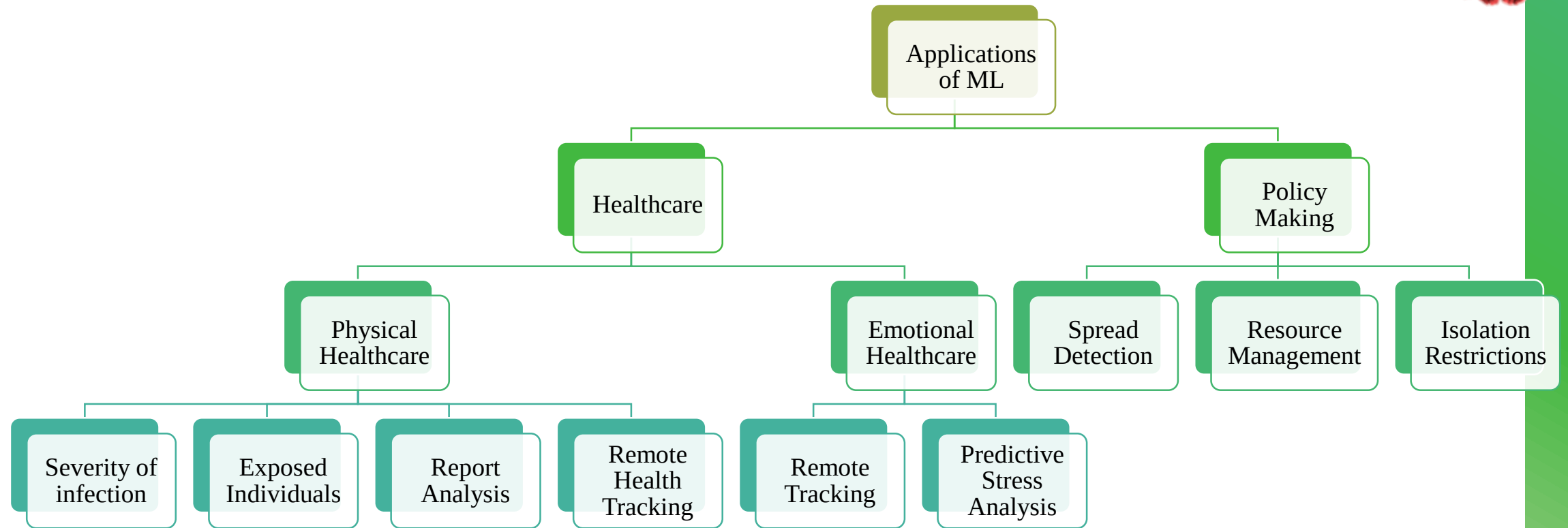
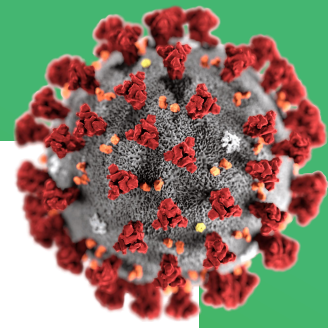
To predict the spread of COVID-19.

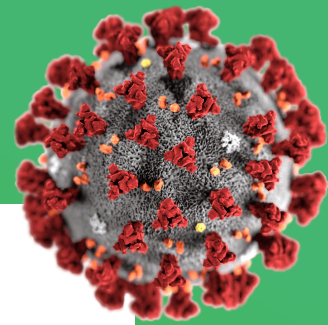
To predict the severity of COVID-19 infection in individuals.

To analyze the perspective exposed persons with virus.

To detect the effect of COVID-19 on peoples' emotional health.

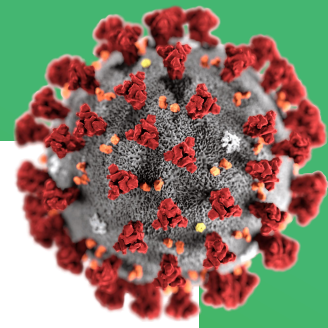
To help make better policies.





ML for Predicting the Spread

- + Focus on Transmission phase of Infection.
- + Multiple Machine Learning Techniques has been applied by various researchers.
- + Some of the widely employed algos are SVM, Random Forest, Regression, LSTM.
- + SUTRA is the most accurate predictive model for predicting the COVID spread.



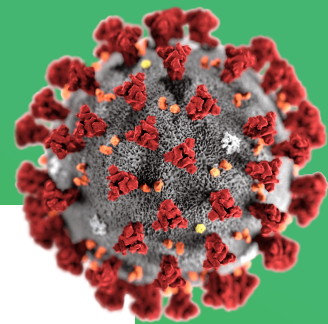
Spread of COVID -19

**Identifying
who is most at
risk from
COVID-19.**

Infection risk: What is the risk of a specific individual or group getting COVID-19?

Severity risk: What is the risk of a specific individual or group developing severe COVID-19 symptoms or complications that would require hospitalization or intensive care?

Outcome risk: What is the risk that a specific treatment will be ineffective for a certain individual or group, and how likely are they to die?



Application of ML in fight to COVID-19

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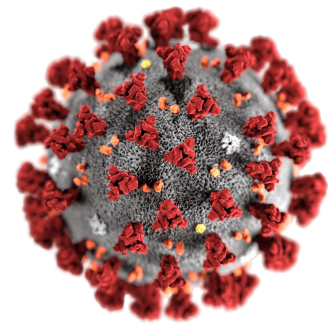
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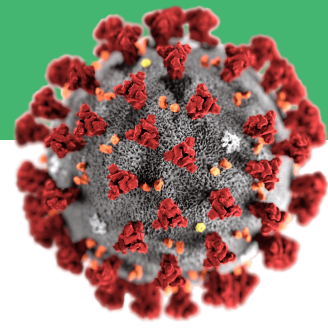
To help make better policies.



Predicting the risk/severity of infection



- + Age
- + Pre-existing conditions
- + General hygiene habits
- + Social habits
- + Number of human interactions
- + Frequency of interactions
- + Location and climate
- + Socio-economic status



Predicting who is at risk of developing a severe case

1

Analyzing
the medical
history of the
patient.

2

Detecting the
variant and
its effects.

3

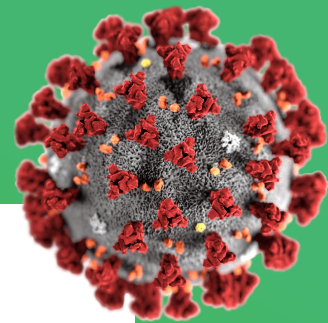
Evaluating
the initial
healthcare
received.

4

Taking
Family
History into
account.

5

Classifying
the image
scans (CT
Scan)



Application of ML in fight to COVID-19

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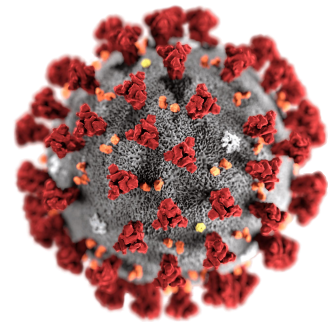
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To help make better policies.



Predicting Exposure to Virus



On detection of covid positive.



Trace recent human contacts.



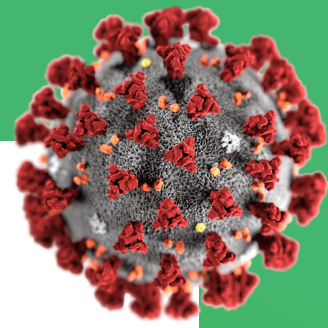
Alert and isolate the exposed individuals.



Remote track the physical health of exposed individuals.

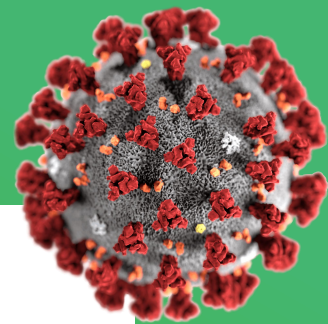


GPS, Bluetooth can be used to trace human contacts.



Predicting Exposure to Virus

- + Madoery et. al. have used the Bluetooth Low Energy (BLE) signals for feeding to machine learning models along with other phone sensor signals for contact tracing.
- + It analyze whether the contact with infected person occurs indoor or outdoor.
- + They designed and developed a custom app targeted to generate and scan BLE, and conducted a series of measurements campaigns under different scenarios comprising different environments (i.e., outdoor or indoor) and multiple distances between the devices (from 0 to 4 m).
- + They assess the gain of introducing multiple features for each environment to better understand which one is more sensitive to feature selection, and the required number of features in each case.
- + They also analyzed the influence of the environment (indoor or outdoor) on proximity estimation accuracy in order to determine its role in these models, and to identify the need of contact tracing apps that can be context-aware.



Application of ML in fight to COVID-19

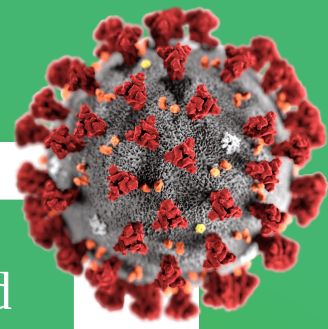
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COVID Psychological Stress

As the world combats with the outrageous and perilous novel coronavirus, social restrictions, minimal & limited physical meetings, and isolation are necessary for public health, but on the flip side, it is detrimental for people's mental health.

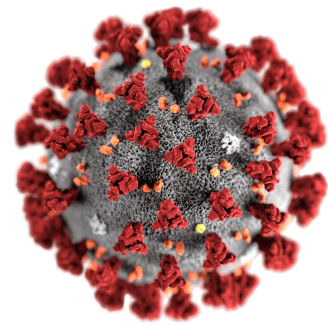
Though stress and sadness are normal and natural responses to COVID-19, self-isolation, social distancing, quarantine, and a national lockdown can all be emotionally challenging.

People are experiencing mental health crisis with this new sudden arrangement.

The psychological effects can lead to a range of reactions from fear to anxiety, from boredom to depression, from frustration to anger, from stigmatization to repulsion.



Prediction of Psychological Well-being



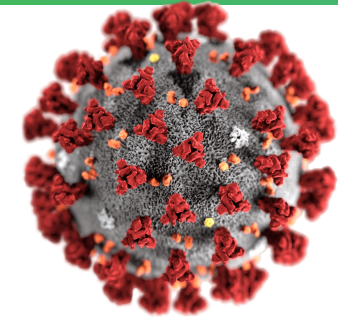
- + Researchers have worked on phenomenological studies to analyze the psychological and emotional well-being of individuals, but an exponential increase has been seen during the pandemic due to upsurge in stress and anxiety encounters in individuals.
- + Socio-linguistic activities have been monitored remotely for change in stress levels of the individuals.
- + Physiological signals like heart rate, sleeping pattern, temperature can better track the psychological state, but since during pandemic the clinic base studies were not feasible, most of the research has been conducted on questionnaire-based datasets, or by analyzing the social and linguistic activities of subjects on the social networking sites.



ML Techniques Employed

- + Neural Network
- + Random Forest
- + XGBoost
- + SVM
- + Bayesian Network

Applications



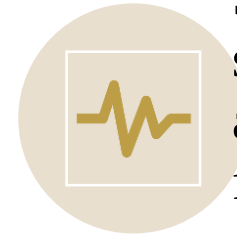
Remote psychological well being tracing data maintained.



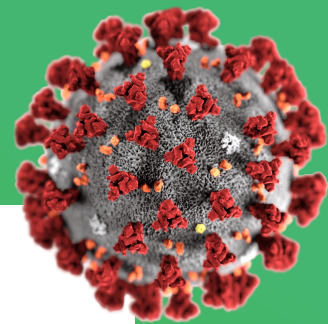
Better Policies can be made for managing the psychological well-being of employees, students.



A support system can be provided for the critical cases.



Seek professional support if symptoms of Corona-related anxiety impair daily functioning or personal/professional relationships.



Application of ML in fight to COVID-19

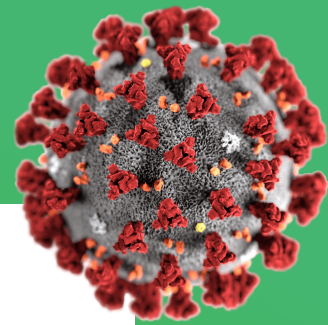
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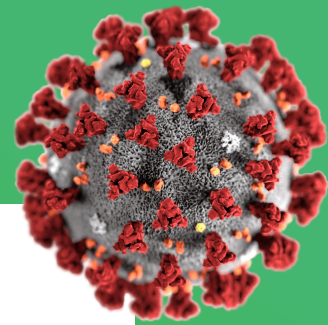
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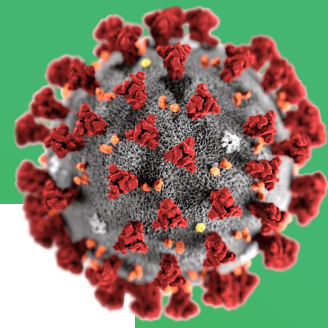
ML for Policy Making

- + People response can be collected through online platforms.
- + Natural Language processing plays an eminent role in analyzing the response.
- + Feedback on the policies implemented can help policy makers to make reforms.



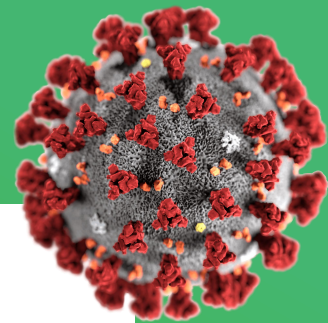
ML for Policy Making

- + During Covid pandemic, a lot of lives has been lost due to lack of resources, like hospital beds, oxygen cylinders, ventilators.
- + With prediction of Covid spread using ML algorithms, resource management can be ensured.
- + With the prediction of severity of the infection, the critical resources can be prioritized to severally ill patients.



Applications

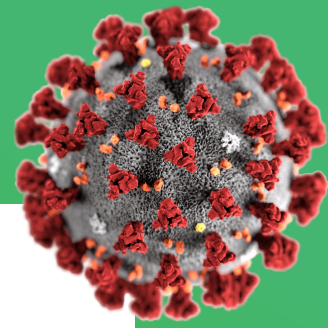
- + Model predictions can be used to formulate vaccination and medical infrastructure strategies.
- + Oxygen consumption monitoring Portal can track usage of oxygen support, hospitals and patients.
- + Priority can be set to patients based on severity, for critical resources.



Real-Time Applications

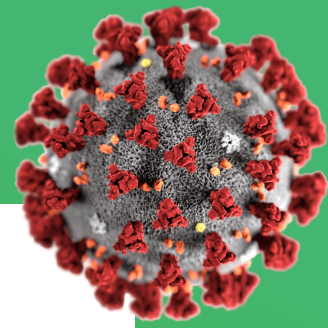
Along with researchers developing more accurate machine learning algorithms, some real-time applications has also been developed for effective management of the COVID-19 pandemic.

- + SUTRA
- + SIR
- + Contact Tracing
- + Fake News Identification



SUTRA

- + Susceptible, Undetected, Tested (positive), and Removed Approach.
- + Developed By M Agrawal and team from IIT Kanpur.
- + Is a Mathematical Model.
- + Predicted the second wave of COVID-19 in India efficiently.
- + Updates the prediction on the basis of daily received data.



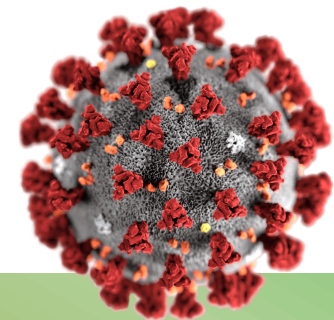
SUTRA

- + Patient population is divided into Asymptomatic and Infected.
- + SUTRA also incorporates that there are a large numbers of undetected asymptomatic patients.
- + It takes into account the spatial spread of a pandemic over time using “reach”.
- + Predicts the spread using the daily new infections data series received from covid19india.org.



SIR – COVID-19 PREDICTION MODEL

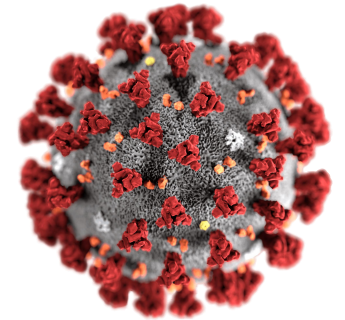
- + Susceptible- Infected-Removed Model to estimate the peak.
- + A data-driven approach based on past outbreaks is used to predict the decline of the epidemic.
- + <https://covid19-forecast.org>





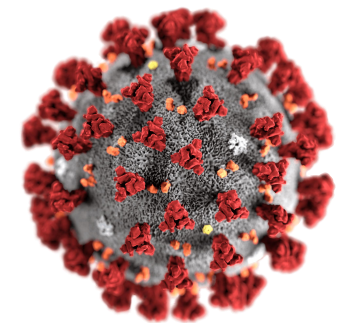
CONTACT TRACING AND FAKE NEWS VERIFICATION APP (by IIT Kanpur)

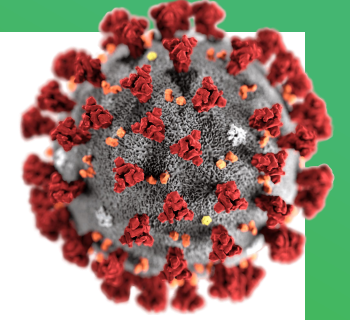
- + Identification of the potentially infected individuals via contact-tracing.
- + Real-time health monitoring.
- + Live-tracking of home quarantined individuals.



Cont.

- + User-friendly fake information detection system for social media platforms.
- + Fact-checked via simple message forwarding.
- + Can be used with non-smart phone.
- + Deployable in areas of limited telecom connectivity.





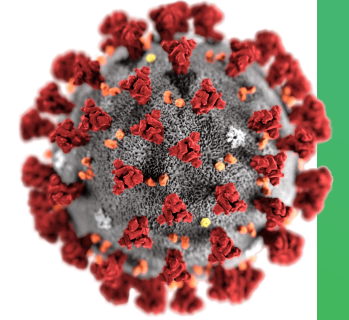
CASE STUDY

- + National COVID Cohort Collaboration (N3C) formed to accelerate the understanding COVID-19 and create a novel approach for collaborative data sharing and analytical data during the pandemic.
- + Random forest and XGBoost models were used to predict severe clinical course.
- + The cohorts included 174,568 adults who tested positive for COVID-19 and a control group of 1,133,848 adults that tested negative. Of the adults that tested positive, 18.6 percent of them were hospitalized and 20.2 percent of those hospitalized had a severe clinical course.
- + The mortality rate of hospitalized patients was 11.6 percent overall and decreased from 16.4 percent in March to April 2020 to 8.6 percent in September to October 2020.



CASE STUDY

- + “Using 64 inputs available on the first hospital day, this study predicted a severe clinical course using random forest and XGBoost models (area under the receiver operating curve = 0.87 for both) that were stable over time. The factor most strongly associated with clinical severity was pH; this result was consistent across machine learning methods.”
- + The machine learning models were able to accurately predict the clinical severity using the commonly collected clinical data from the first 24 hours of a patient’s hospitalization.





Publicly Available Datasets

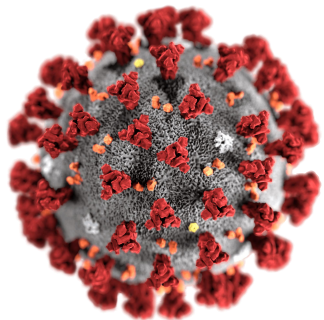
CORD-19 (COVID-19 Open Research Dataset Challenge)- Open research dataset containing over 500000 scholarly articles related to coronavirus.

SARS-CoV-2 Virion and Proteins- developed by NIH/NIAID leading to extremely rapid developments of experimental structures of SARS-CoV-2 virus and its proteins.

Coronavirus3D- web-based viewer offers 3D visualization and analysis of SARS-CoV-2 protein structures with respect to the CoV-2 mutational patterns.



Publicly Available Datasets



CDC COVID Data & Surveillance- Find maps and charts tracking cases, deaths, and trends of COVID-19.

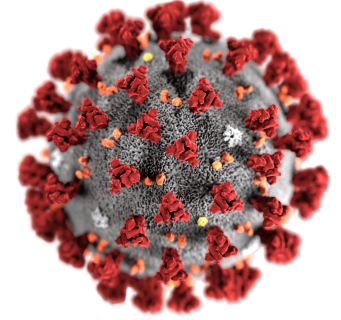
CAS COVID-19 antiviral compounds dataset- contains nearly 50,000 chemical substances includes antiviral drugs and related compounds that are structurally similar to known antivirals for use in applications including research, data mining, machine learning and analytics.

COVID-19 country profile and mobility analysis- comprises sociodemographic characteristics compiled from 35 datasets obtained at UN Data, mobility metrics that can assist the analysis of social distancing from Google Community Mobility Reports, and daily counts of cases and deaths by COVID-19 from the European Centre for Disease Prevention and Control, and the Johns Hopkins University Center for Systems Science and Engineering.

COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University- This is the data repository for the 2019 Novel Coronavirus Visual Dashboard operated by the Johns Hopkins University Center for Systems Science and Engineering



Limitations of ML Predictive Modelling



- + A lot of uncertainties
- + Limited Labelled Datasets
- + Data Privacy
- + Generalization Metrics



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THANK YOU