Special Topics in Design I (Data Driven Design) DSL 810

Quantified Self Self-Tracking
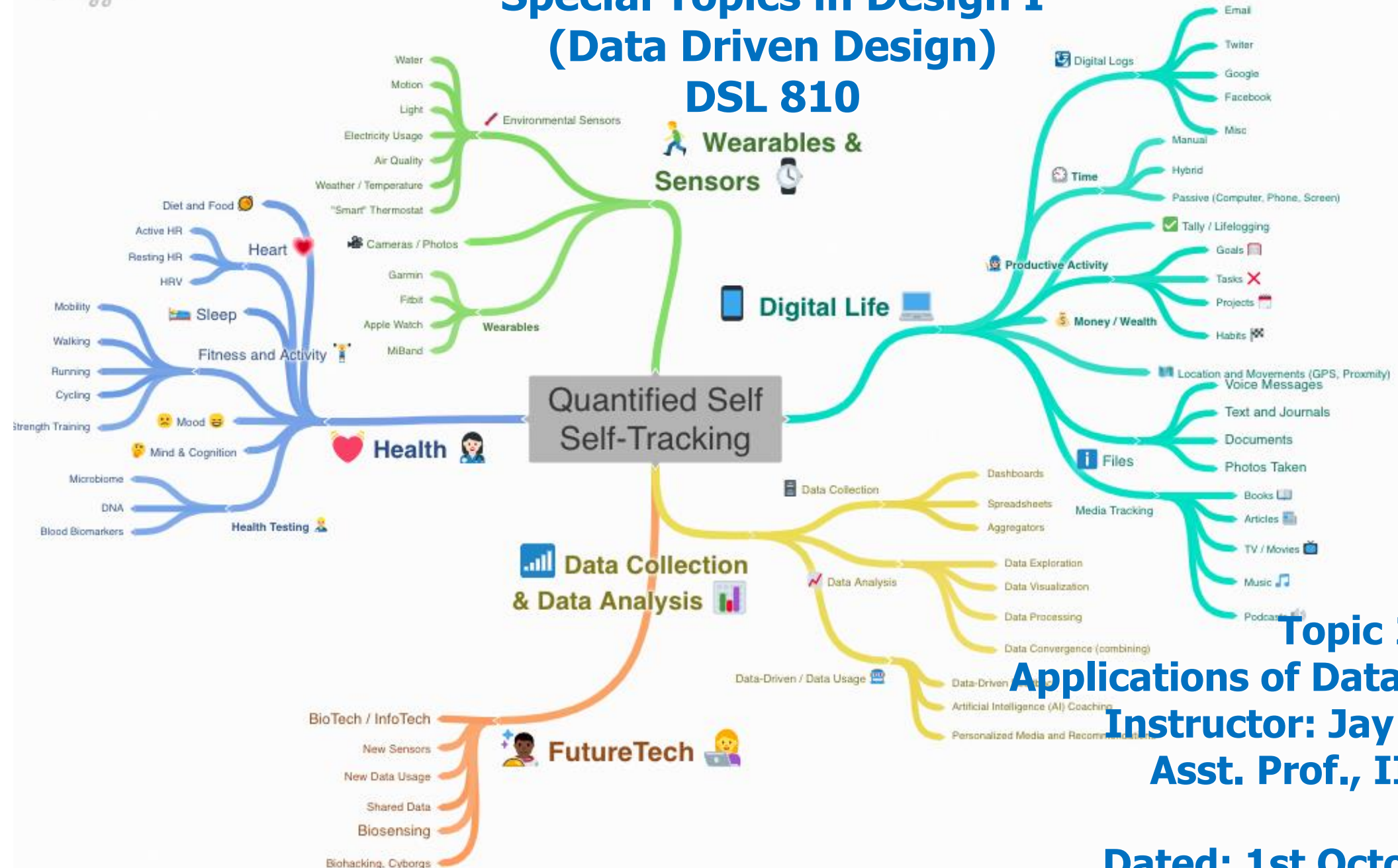
Topic 2
Applications of Data Driven Design
Instructor: Jay Dhariwal, Asst. Prof., IIT Delhi

Dated: 1st October, 2020

Source: http://www.markwk.com/quantified-self-mind-map.html

Case studies for Project Proposal
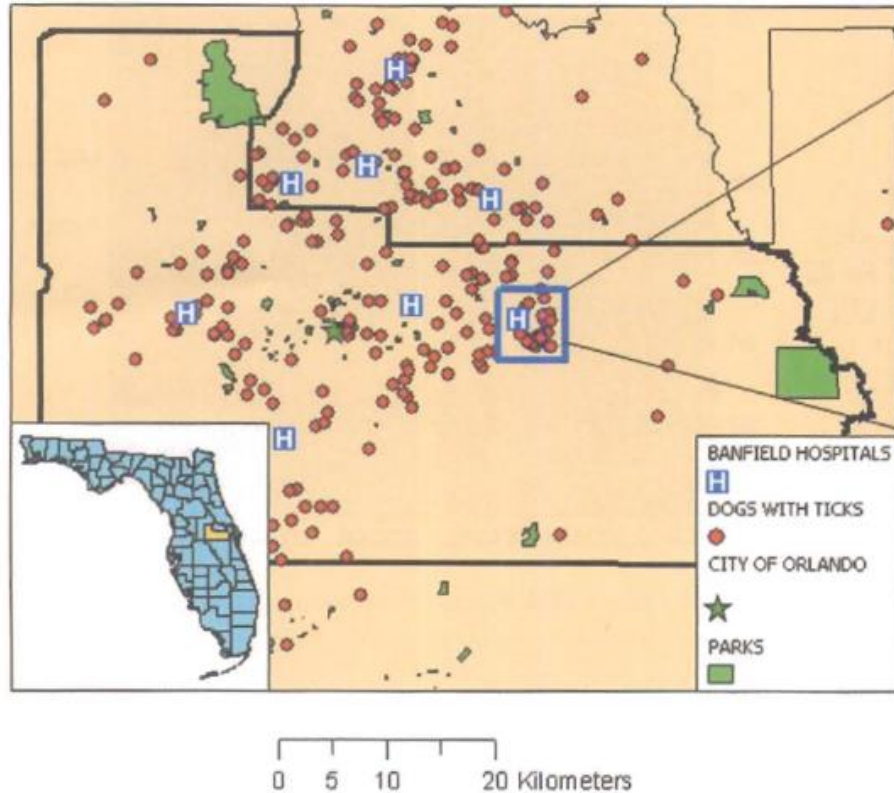
- [Spatio-temporal clusters for early epidemic detection](#) (2004)

- SAS data warehouse data to improve USCG supply chain (2005-08)

- [Machine Learning for Building simulation](#) (2014-15)

- Big Data analysis from MIT North Court study (2016-17)

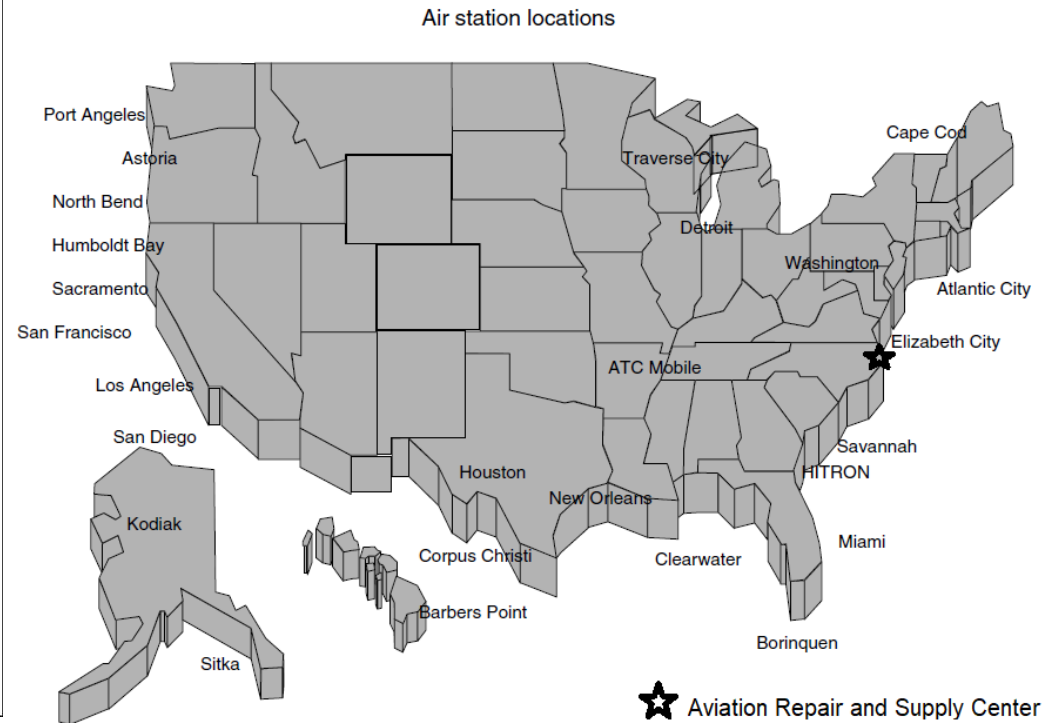- NodeMCU + sensors + ThingSpeak (DSL 810, Spring 2020)

Moore G.E., Ward M.P., **Dhariwal J.**, Wu C.C., Glickman N.W., Lewis H.B., Glickman L.T., 'Development of a national companion animal syndromic surveillance system for bioterrorism', *2nd International Conference on the Applications of GIS and Spatial Analysis to Veterinary Science (GISVET 04), Univ. Guelph, Ontario, Canada*, Durr, P. A. and Martin, S. W., Jun 2004.

Data analysis to improve USCG supply chain
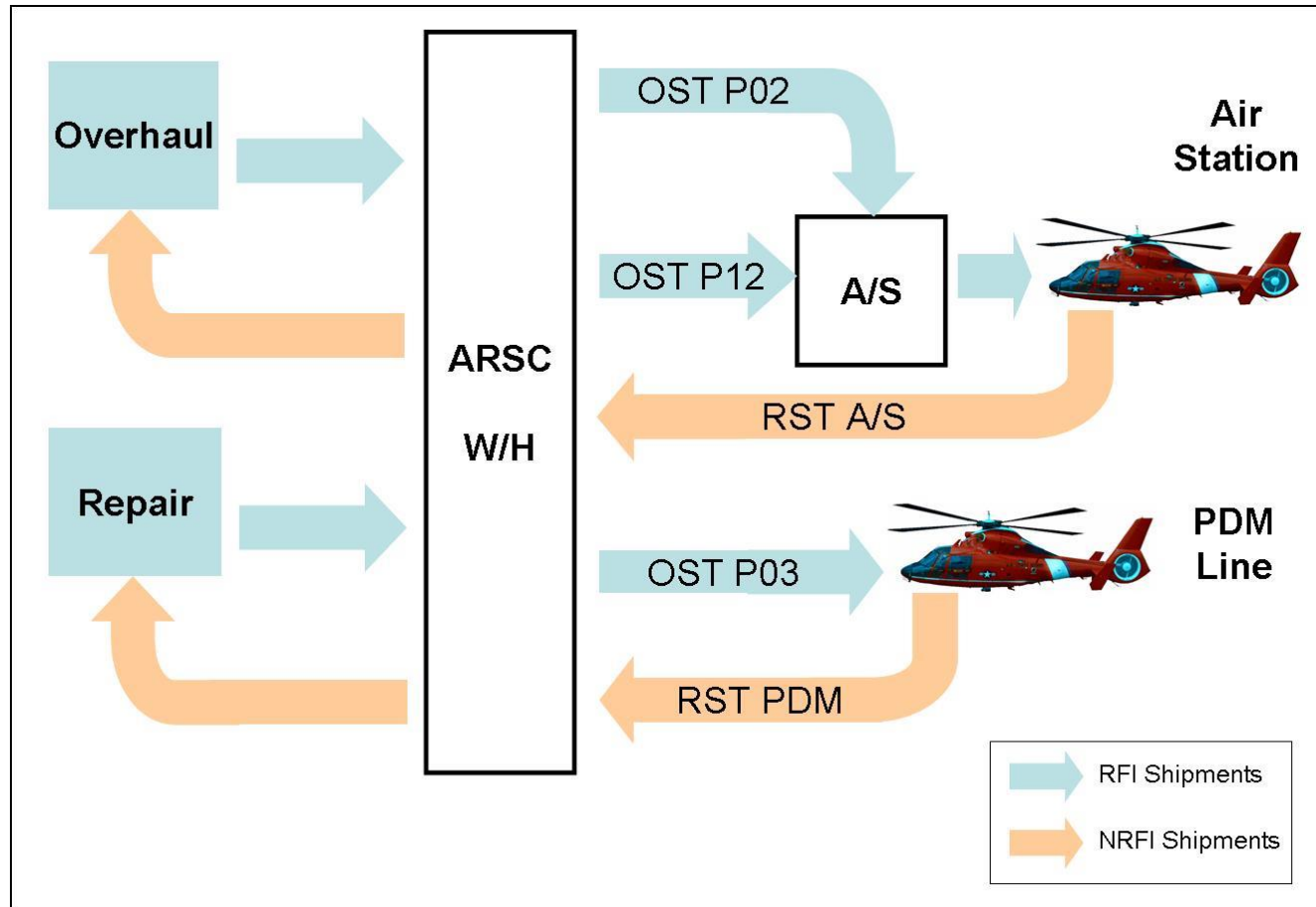
SAS Data Warehouse – over a 100 tables with data for financial, repair, inventory, demand, lead time

The Guardian - movie

Air station locations

Port Angeles
Astoria
North Bend
Humboldt Bay
Sacramento
San Francisco
Los Angeles
San Diego
Kodiak
Sitka
Traverse City
Detroit
Washington
ATC Mobile
Houston
New Orleans
Corpus Christi
Barbers Point
Clearwater
Cape Cod
Atlantic City
Elizabeth City
Savannah
HITRON
Miami
Borinquen

⭐ Aviation Repair and Supply Center

OST P02
Air Station
OST P12
A/S
RST A/S
Overhaul
ARSC W/H
Repair
OST P03
PDM Line
RST PDM

RFI Shipments
NRFI Shipments

Aviation Logistics Center, USCG – Semper Paratus!   Franz Edelman Award   Netherlands Railways 2007 Winner

Solar Decathlon

An international competition, organised by the US Dept. of Energy

First held in 2002 in US; launched in Europe in 2010

20 teams selected from around the world

Design and construction of fully-functional houses powered entirely by solar energy

First team ever from India to have been selected to participate (consortium of IITB and AoA)
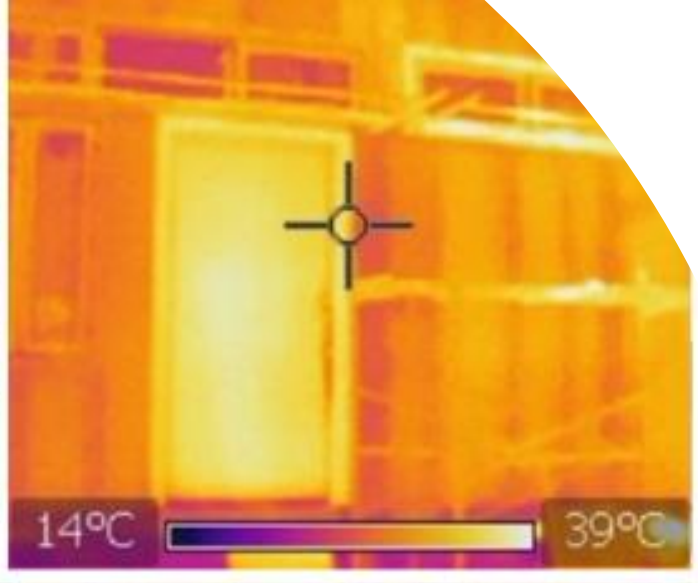
Contest	Points	Contest	Points
Architecture	120	House Functioning	120
Engineering & Construction	80	Communication & Awareness	80
Energy Efficiency	80	Urban Planning	120
Electrical Energy Balance	120	Innovation	80
Comfort Conditions	120	Sustainability	80

House Design: Passive Solar Architecture
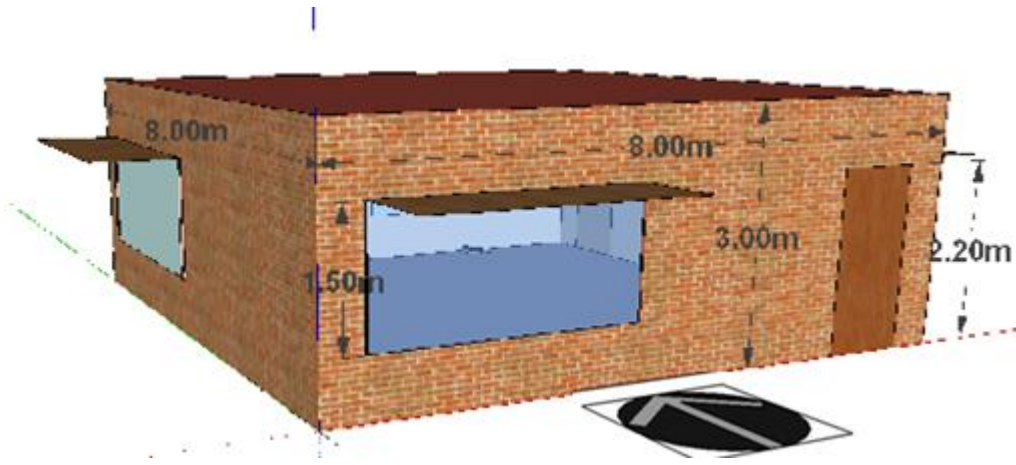

SUN PATH ANALYSIS FOR MUMBAI
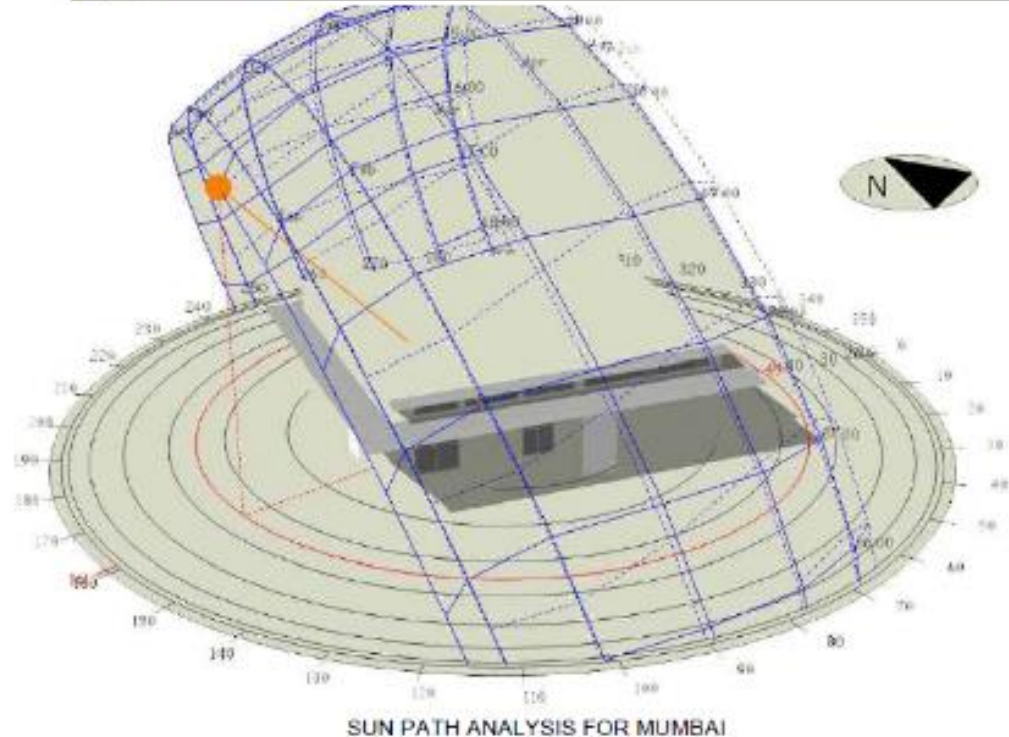
[Time Lapse Video of Construction in France](#)

# Machine Learning for Building Simulation based Optimization

- Trade-off between cost and energy efficiency

- Simulations predict the performance well but take longer.

- Build a machine learning model by training simulation models and use this model for optimization of building design

$$Cooling\ Energy = f\begin{pmatrix} Window\ SHGC, WWR, \\ Roof\ \boldsymbol{\rho}, \\ Roof\ insulation \end{pmatrix} + \boldsymbol{\varepsilon}$$

Dhariwal J. and Banerjee R., 'An approach for building design optimization using design of experiments', *Building Simulation,* 10 (3), *2017,* 323–336. doi

Optimized Building Design

| Design Variable	Range
WWR	15% to 40% (IGBC 2011)
Overhang depth	0 to 1 m (BIS 2005)
Fin depth	0 to 0.5 m
Roof ρ	0.25 to 0.85 (SSEF 2014)
Window SHGC	0.2 to 0.8
Window U-value	1 to 5.8 W/m²K
Curtains SHGC	0.2 to 1.0
Wall insulation thickness (t)	0-0.1 m
Roof insulation thickness (t)	0-0.2 m
Wall additional thermal mass (t)	0-0.1 m
Roof additional thermal mass (t)	0-0.2 m
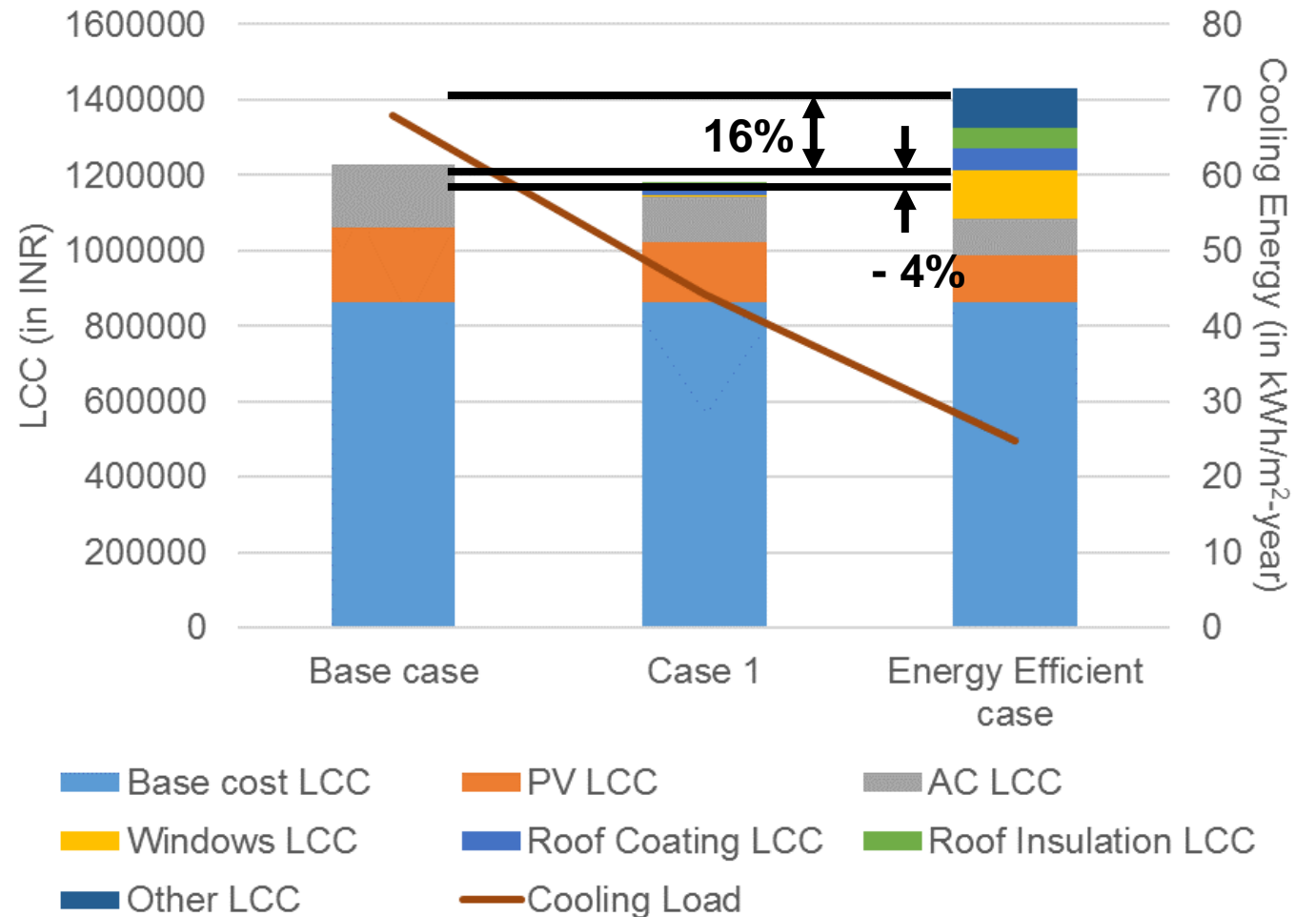
Design of Outdoor Public Spaces

Reinhart C., Dhariwal J. and Gero K., 'Biometeorological indices explain outside dwelling patterns based on Wi-Fi data in support of sustainable urban planning', Building and Environment, 126, 2017, 422–430.

Stata Center cafeteria
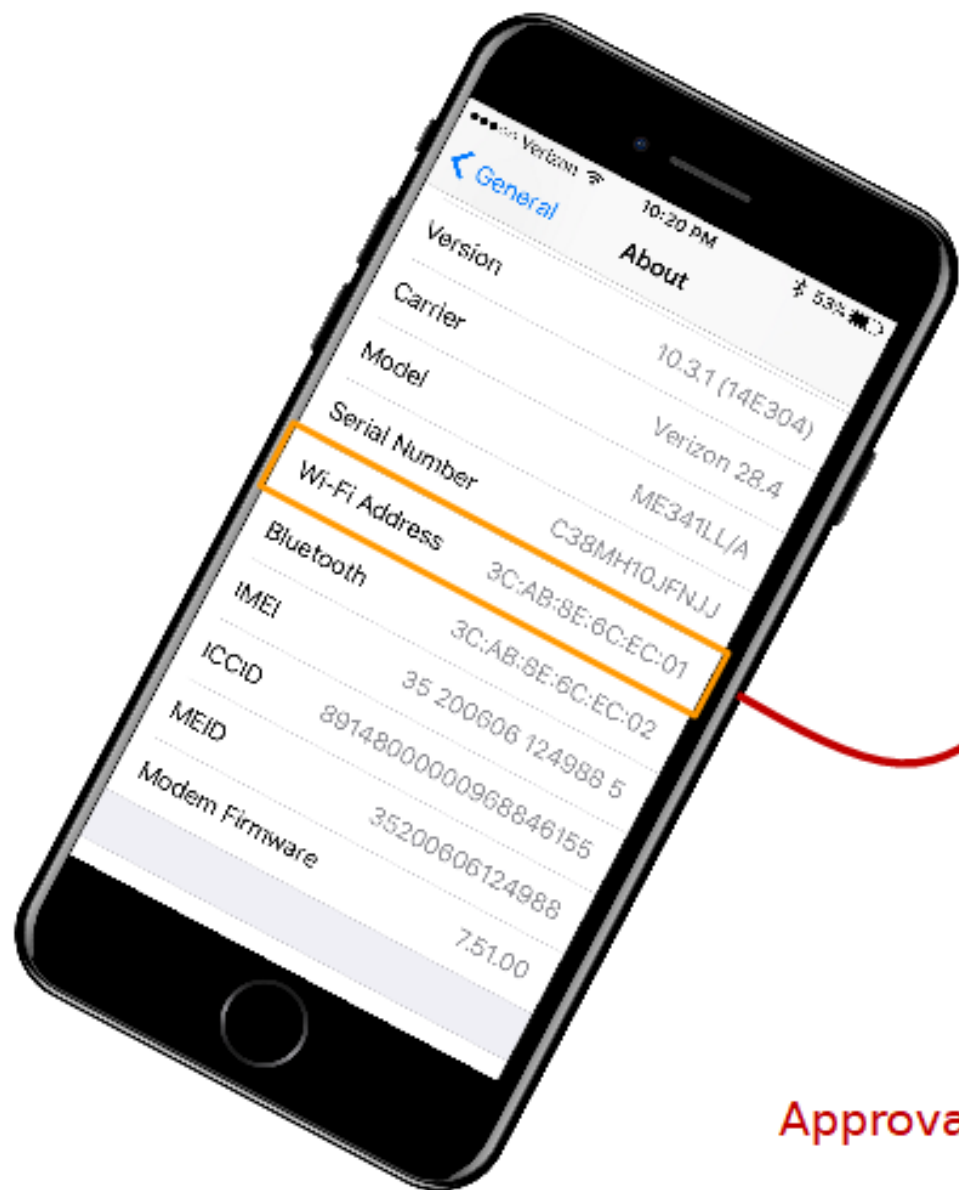
Outdoor seating

Koch cafeteria

Stata Center cafeteria

Outdoor seating

Koch cafeteria

Soofa benches

Weather station at roof of nearby building
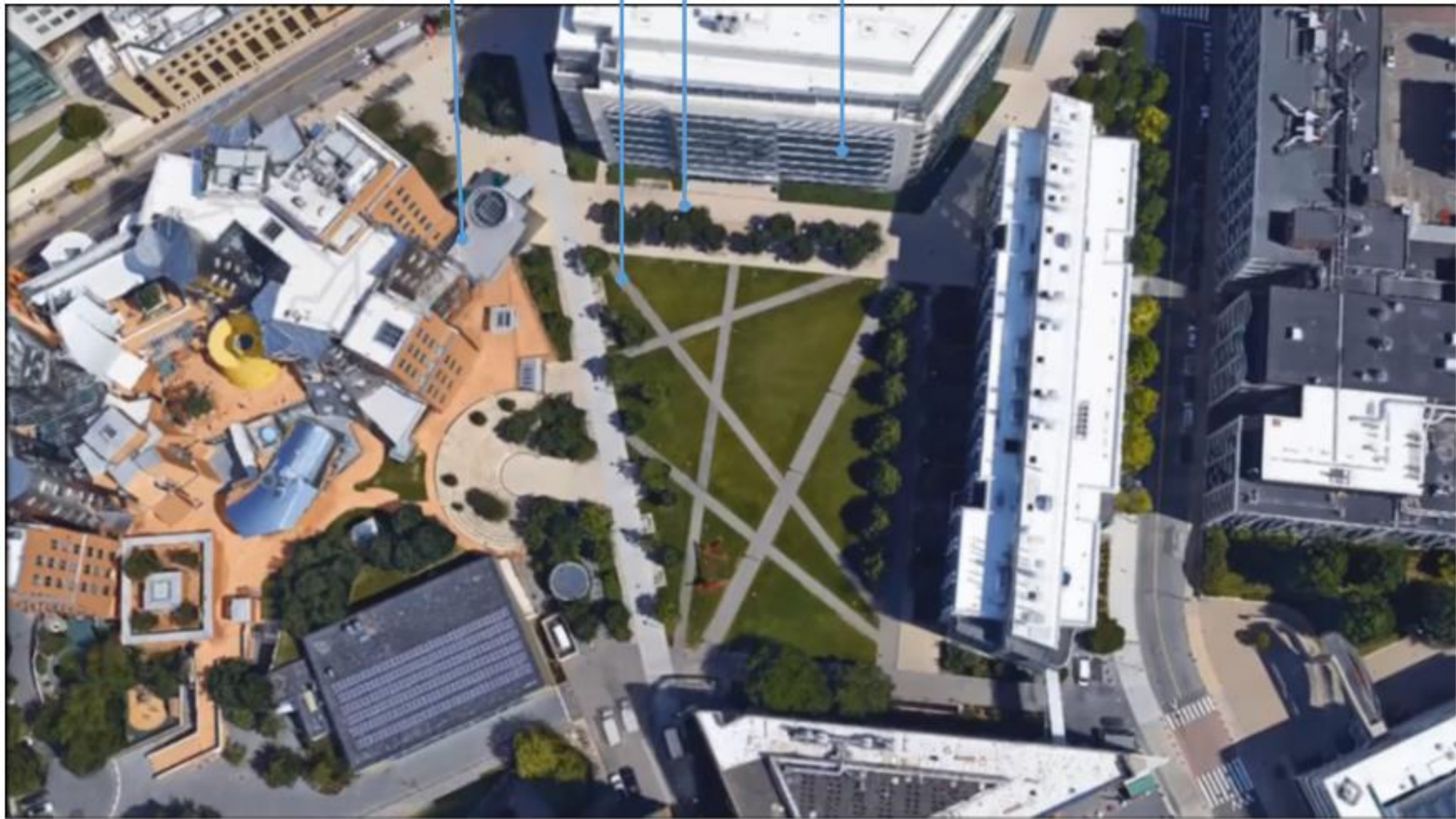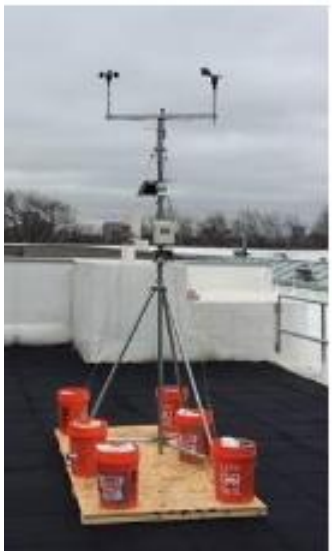
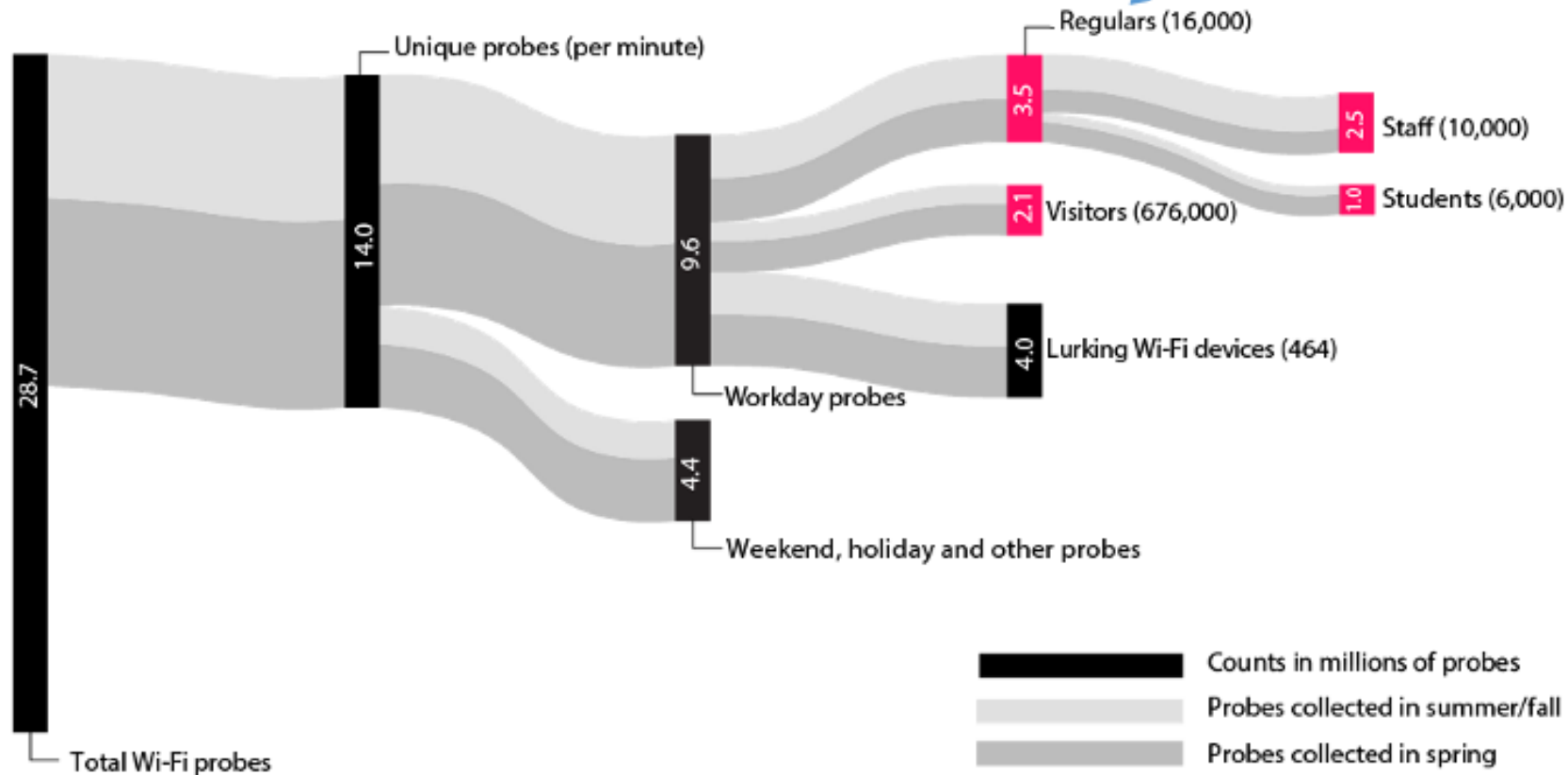# Privacy in the Modern Age

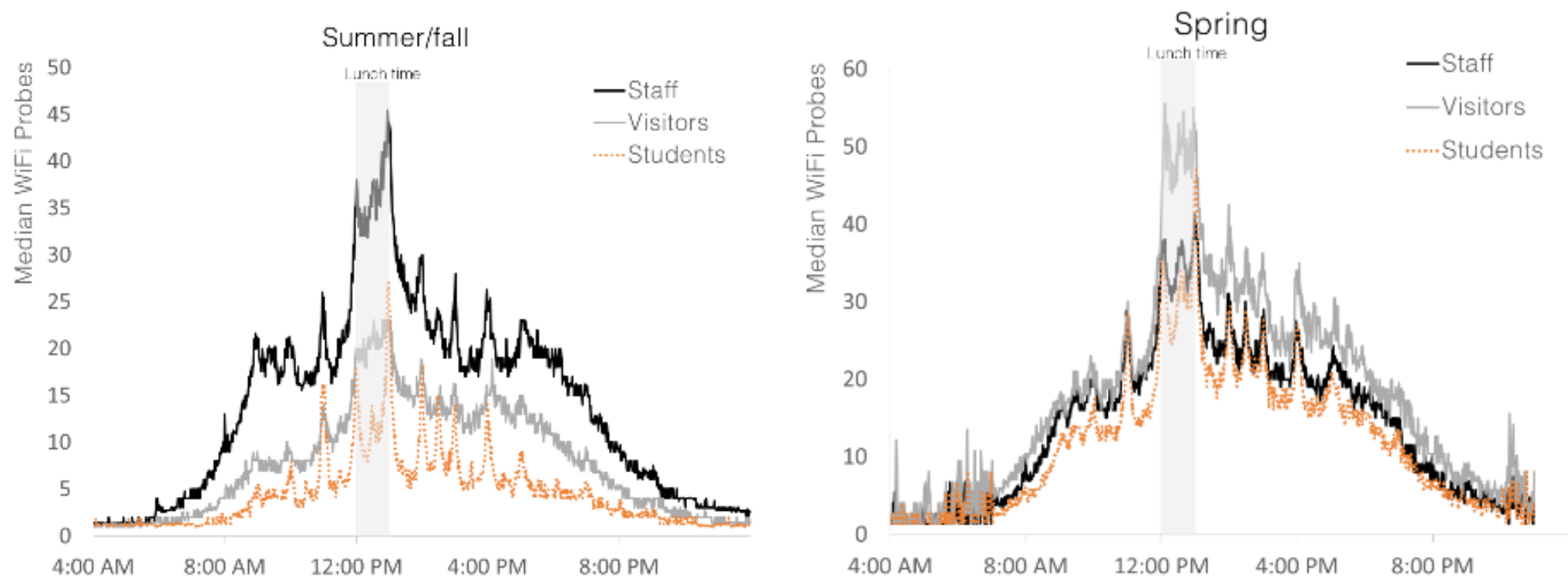| timestamp	encrypted mac_id
10/08/2020 12:00:03	ab-cd-ef-gh-ij-kl
10/08/2020 12:00:40	ab-cd-ef-gh-ij-kl
10/08/2020 12:01:37	ab-cd-ef-gh-ij-kl
10/08/2020 12:02:45	ab-cd-ef-gh-ij-kl
10/08/2020 12:06:03	ab-cd-ef-gh-ij-kl
10/08/2020 12:09:34	ab-cd-ef-gh-ij-kl
10/08/2020 12:14:43	ab-cd-ef-gh-ij-kl

Encrypted device ID

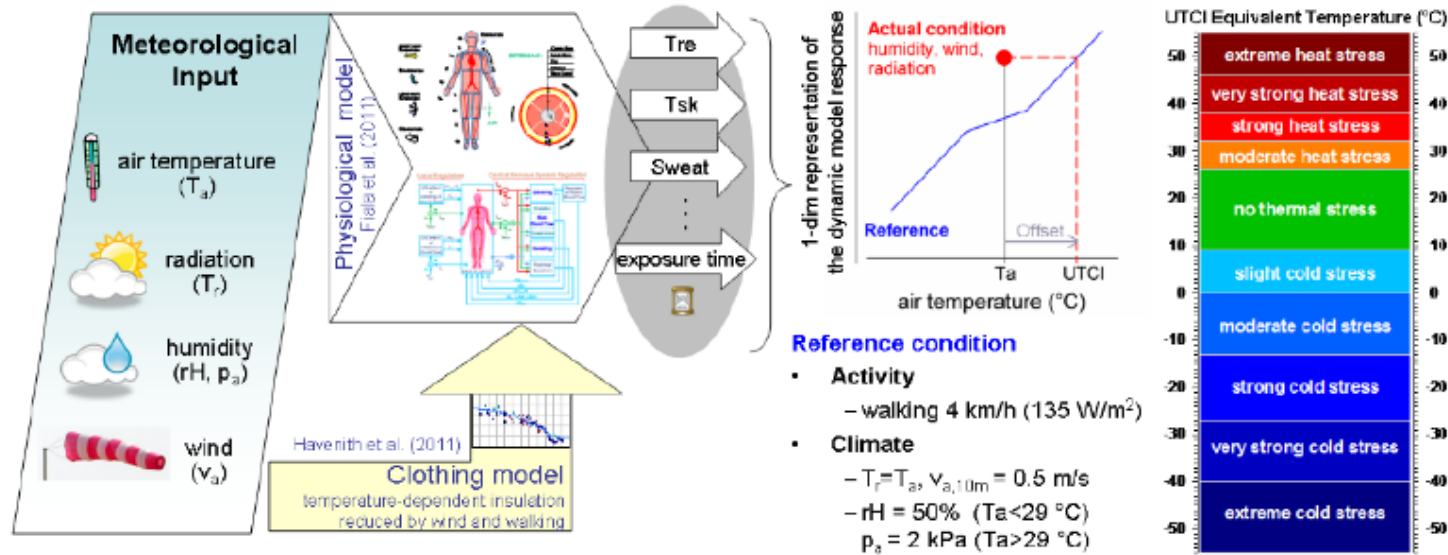Approvals from COUHES at MIT

Results from July 2016 – May 2017

400 times more longitudinal subjects than any study in the past

Unique probes (per minute)

Regulars (16,000)

Staff (10,000)

Students (6,000)

Visitors (676,000)

Workday probes

Lurking Wi-Fi devices (464)

Weekend, holiday and other probes

Total Wi-Fi probes

28.7

14.0

9.6

4.4

3.5

2.5

1.0

2.1

4.0

Counts in millions of probes

Probes collected in summer/fall

Probes collected in spring

Hourly Occupancy Profiles

Universal Thermal Climate Index (UTCI)

Source: (Kampmann et al., 2011)
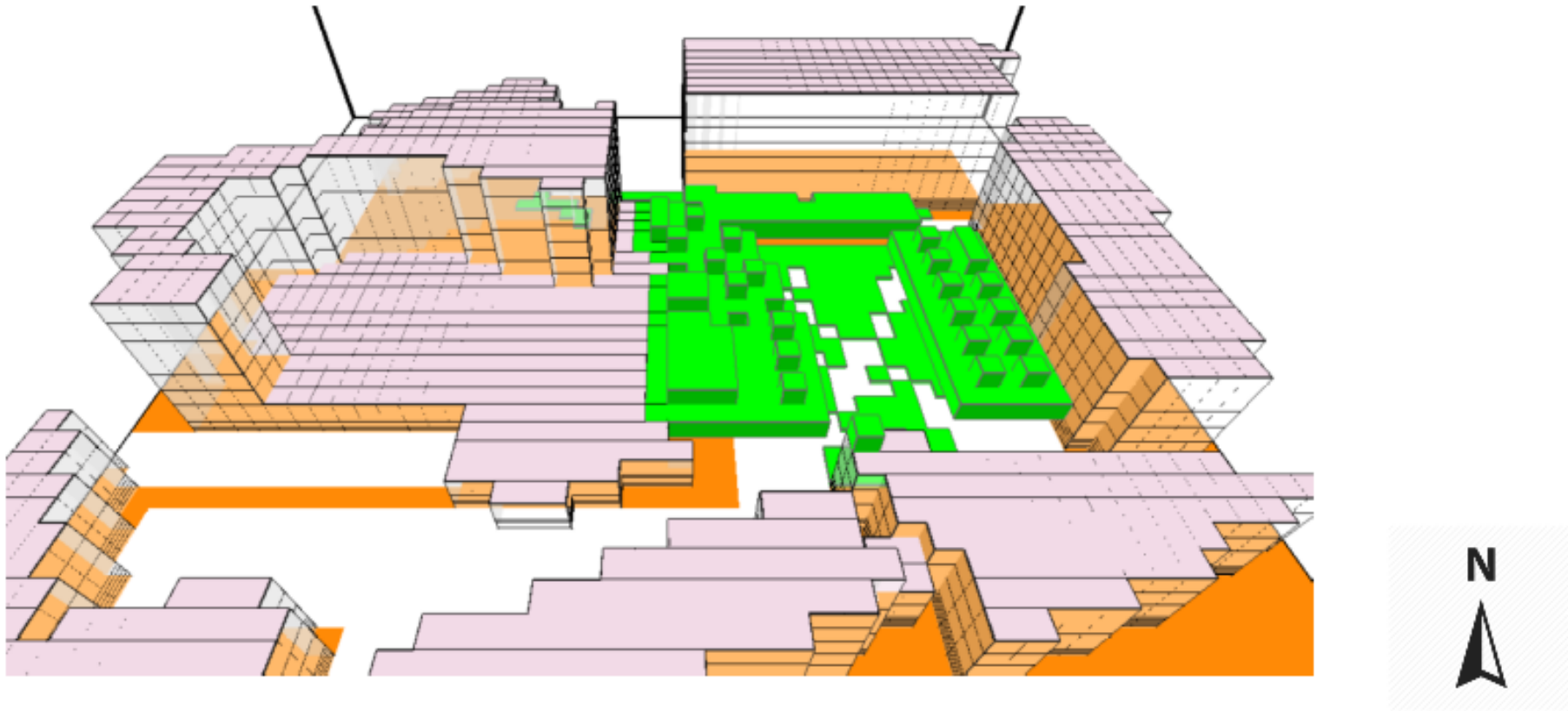
- Fiala developed a 340 node thermal comfort model.
- Mean radiant temperature and clothing model are key inputs.
- Simplified model under: http://www.utci.org/utcineu/utcineu.php
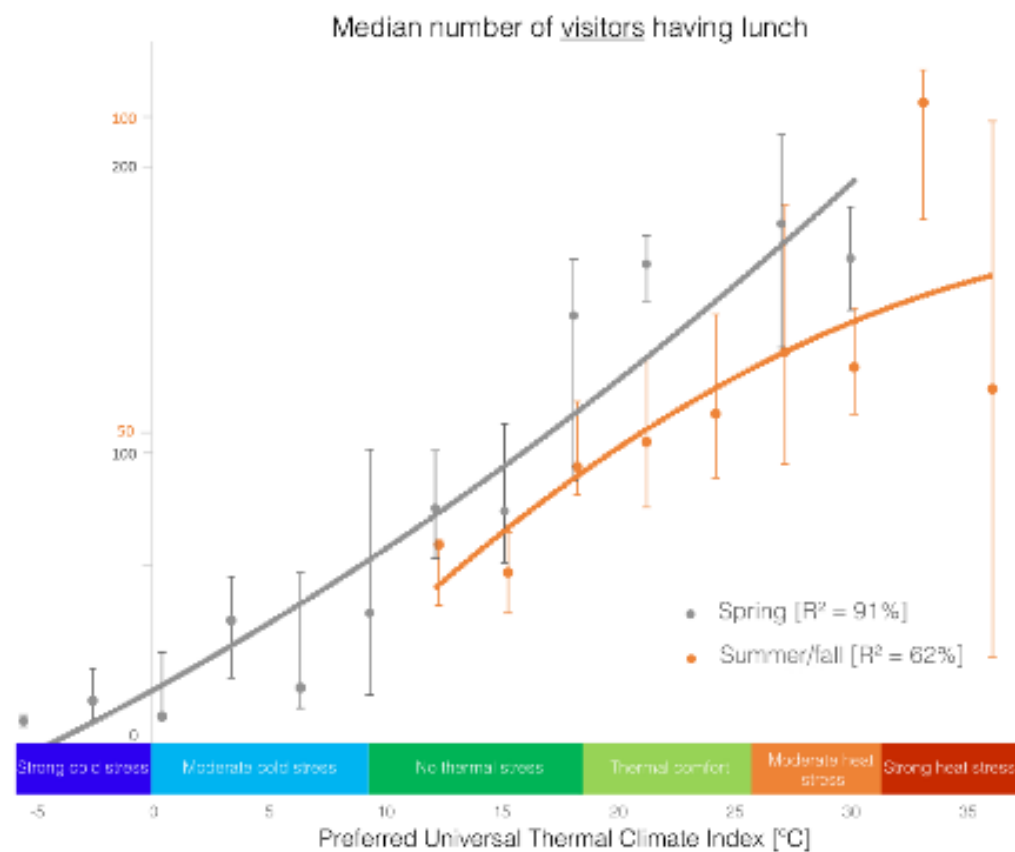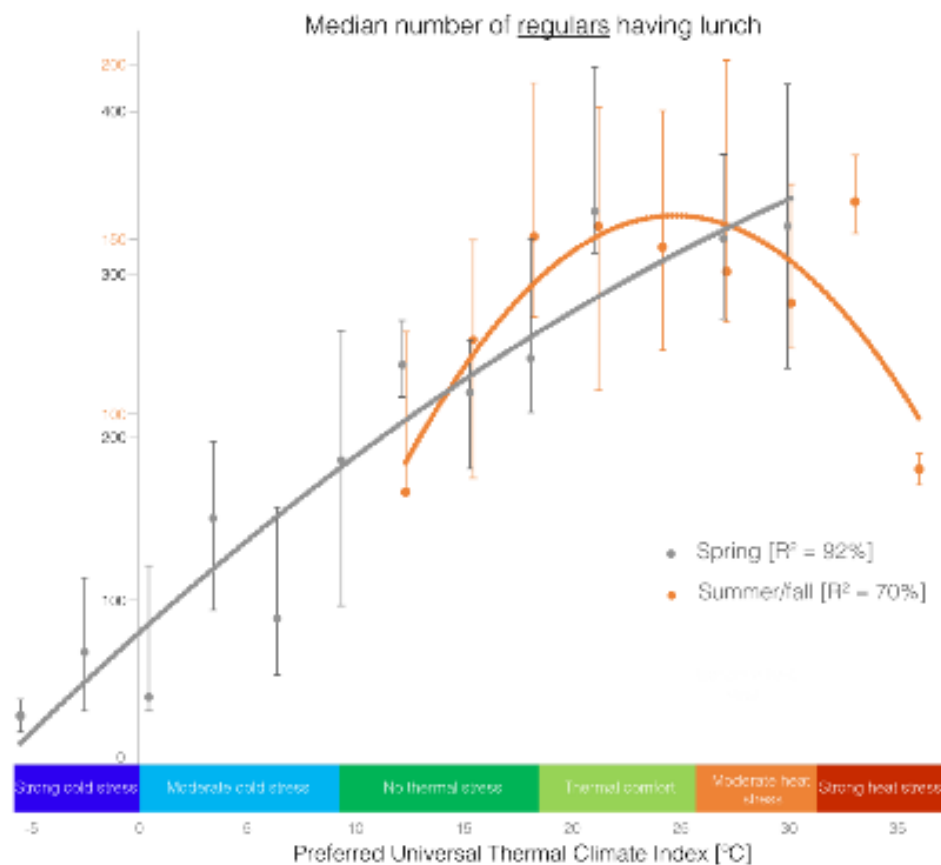
UTCI Calculations in ENVI-met v4.0

❏ Considers: Longwave and short radiation (MRT), temperature, relative humidity and wind
❏ Hourly ENVI-met calculations from July 2016 to May 2017

☐ Simulations for July 6 2016 from morning to evening (shaded vs. unshaded)

Video link

Regulars vs. Visitors (Lunch Breaks)

- UTCI explains > 70% of variance for likelihood for regulars having lunch
- Regulars vs. Visitors behavior, Differences in fall and spring
- Enormous potential for influencing the design of outdoor urban spaces
- Replicated this work for hot, arid climate of Masdar Institute, Abu Dhabi.

- **Dhariwal J.**, Manandhar P., Bande L., Marpu P., Armstrong P. and Reinhart C., 'Evaluating the effectiveness of outdoor evaporative cooling in a hot, arid climate', *Building and Environment*, 150, 2019, 281-288. doi

# Heat Index profile for my room NodeMCU + DHT11 + ThingSpeak

Observations
1. 48500 data points
2. T, Rh every 18 sec for 10 days
3. Cyclical pattern
4. Daily Temperature Increase
5. In the context of COVID-19, this analysis may help to know what Temp, Rh to avoid which is conducive for the virus

Other applications

- [Marta González - Mobile Data for Urban Transformation](#) (Targeted decongestion to reduce travel time by 16% vs. 1% - 32 minutes vs. 2 minutes)

- [Big Problems, Big Data Solutions](#) (Deb Roy, MIT Media Lab Laboratory for Social Machines; MIT; Twitter – US elections 2016)

- [Deb Roy (TED talk: birth of a word)](#)

- [3D map of the city with aerial LIDAR and AI Mapdwell](#)

- Gulshan's research work on use of satellite data for outdoor air quality monitoring

- [Automatic music generation (Ayush Pandey: DSL 810 Spring 2020)](#)

- [Speech sentiment analysis (Saksham Saxena: DSL 810 Spring 2020)](#)

Understanding congested travel in urban areas [Serdar Çolak](#), [Antonio Lima](#) & [Marta C. González](#), *Nature Communications* **volume 7**, Article number: 10793 (2016)
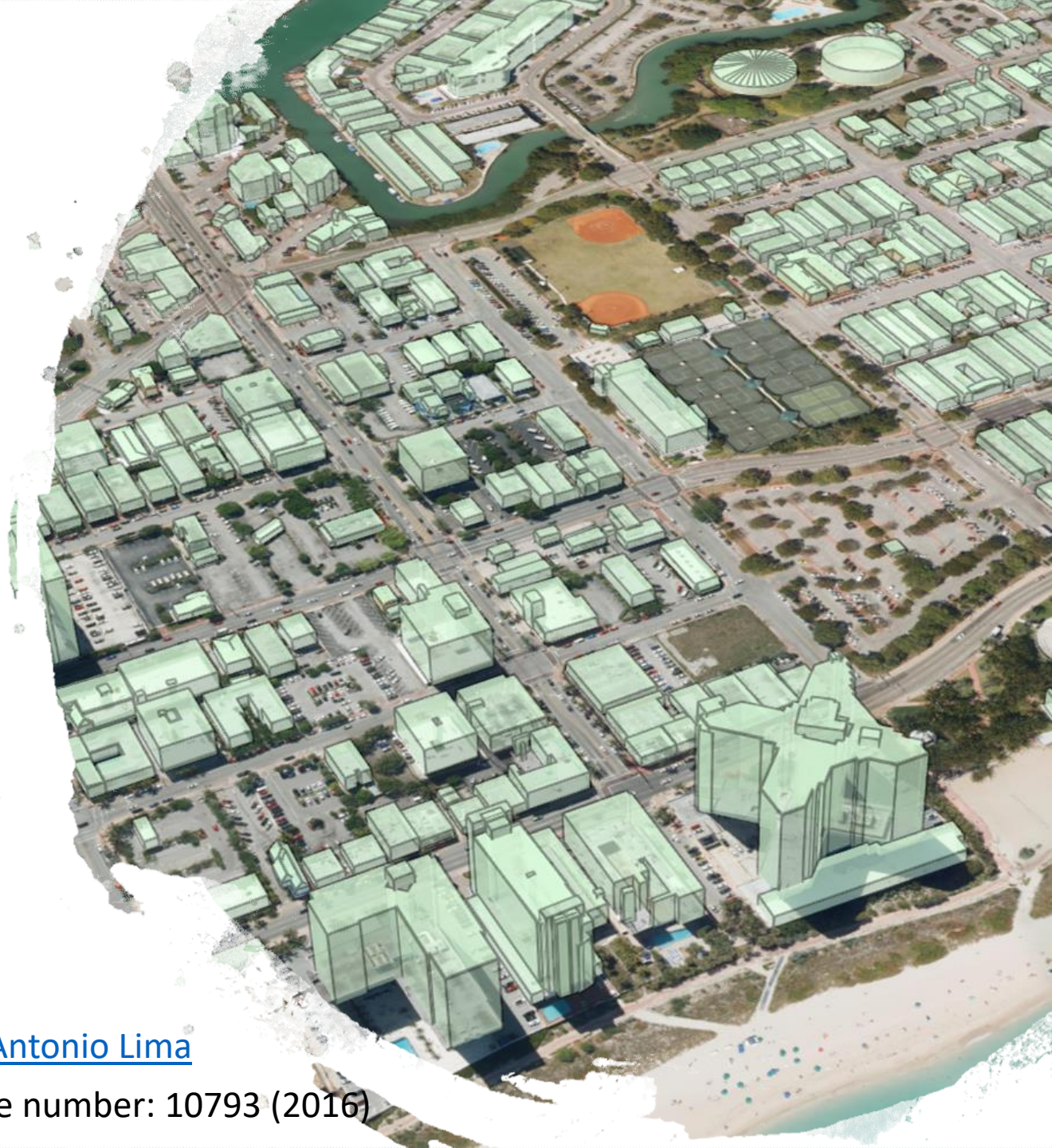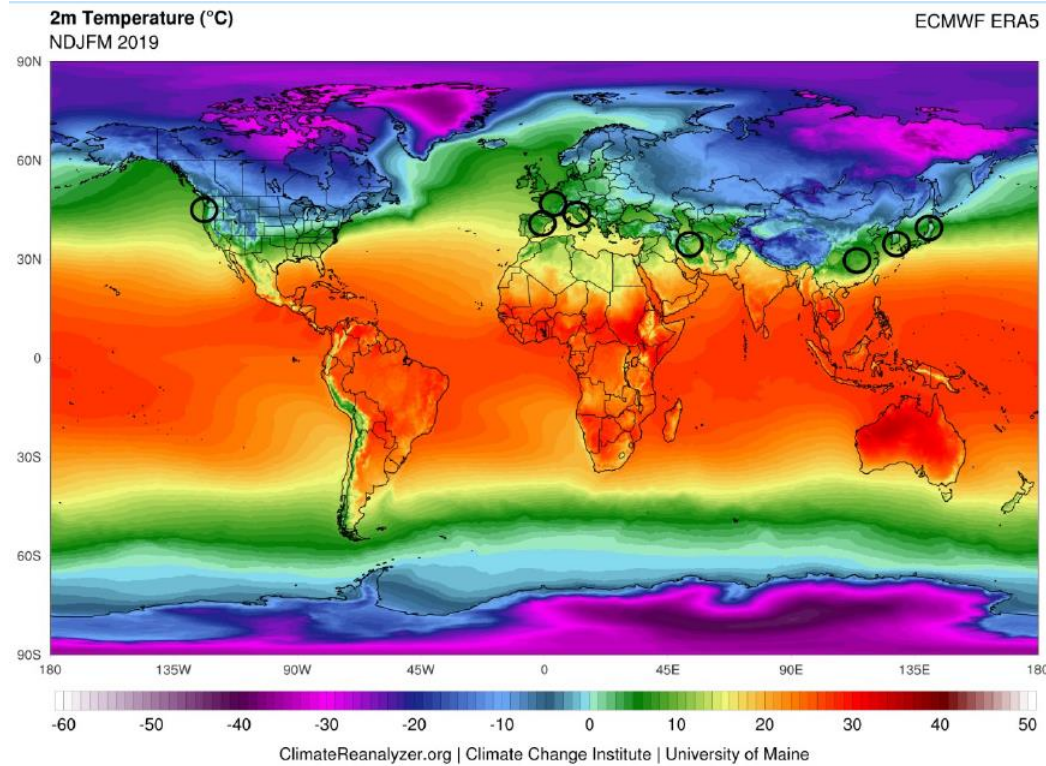
Why is COVID-19 spreading the way it is?

Figure 1. World temperature map November 2018-March 2019. Color gradient indicates 2-meter temperatures in degrees Celsius. Black circles represent countries with significant community transmission (≥ 10 deaths as of March 10, 2020). Image from Climate Reanalyzer (https://ClimateReanalyzer.org), Climate Change Institute, University of Maine, USA.

- Regions between 30 ° to 50 ° Latitude had the Temperature (5-11 °C), Rh (44-84%) in Jan, Feb 2020 for virus to spread
- Predictions for March and April from this paper – The virus spread would potentially move northwards to UK, North-Eastern USA, Manchuria belt
- Can we use this domain knowledge to have predictions for India using machine learning?
- [Effect of meteorological factors on COVID-19 spread](#)   [Files](#)

Source: Sajadi, Mohammad M. and Habibzadeh, Parham and Vintzileos, Augustin and Shokouhi, Shervin and Miralles-Wilhelm, Fernando and Amoroso, Anthony, Temperature, Humidity and Latitude Analysis to Predict Potential Spread and Seasonality for COVID-19 (March 5, 2020)

Effect of meteorological factors on COVID-19 spread

- This project intends to build a data science based model to study the spread of COVID-19 in India based on meteorological and other factors

- COVID-19 spread = f(average daily T_{air}, diurnal temperature range, humidity, sunlight, wind speed, precipitation, day number, lockdown strategy – mobility, population density, fraction of population > 65 years of age, quality of health care, GDP, GDP per capita, HDI, viral factors) = predictor variables

- COVID-19 response variables = cases, deaths, R-number, cases/population, deaths/population, cases/tests, deaths/tests

- This would help in predicting the areas at greater risk of community spread in the coming months, allowing to focus public health efforts accordingly.

- A long term view on this project can be taken to build a decision support system which would be helpful with future pandemics as well

Literature review for the COVID-19 spread project

- Araujo, Miguel B., and Babak Naimi. 2020. "Spread of SARS-CoV-2 Coronavirus Likely to Be Constrained by Climate." MedRxiv, https://doi.org/10.1101/2020.03.12.2003472

- Ma, Yueling, Yadong Zhao, Jiangtao Liu, Xiaotao He, Bo Wang, Shihua Fu, Jun Yan, Jingping Niu, Ji Zhou, and Bin Luo. 2020. "Effects of Temperature Variation and Humidity on the Death of COVID-19 in Wuhan, China." Science of the Total Environment 724. https://doi.org/10.1016/j.scitotenv.2020.138226.

- Wang, Jingyuan, Ke Tang, Kai Feng, and Weifeng Lv. 2020. "High Temperature and High Humidity Reduce the Transmission of COVID-19." SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3551767.

- Breton, Theodore R. 2020. "The Effect of Temperature on the Spread of the Coronavirus in the U.S." SSRN Electronic Journal, no. March. https://doi.org/10.2139/ssrn.3567840.

- Yan, Ning Ning, Tian Yu Zhang, and Xiao Jun Li. 2020. "Synthesis of 1, 2, 2, 6, 6-Pentamethylpiperidinol." Xiandai Huagong/Modern Chemical Industry 40 (5): 186–89. https://doi.org/10.16606/j.cnki.issn0253-4320.2020.05.040.

- Xu, Bo, Bernardo Gutierrez, Sumiko Mekaru, Kara Sewalk, Lauren Goodwin, Alyssa Loskill, Emily L. Cohn, et al. 2020. "Epidemiological Data from the COVID-19 Outbreak, Real-Time Case Information." Scientific Data 7 (1): 1–6. https://doi.org/10.1038/s41597-020-0448-0.

- Sajadi, Mohammad M, Parham Habibzadeh, Augustin Vintzileos, Fernando Miralles-wilhelm, and Anthony Amoroso. 1992. "This Preprint Research Paper Has Not Been Peer Reviewed. Electronic Copy Available at: Https://Ssrn.Com/Abstract=3550308," no. 410: 6–7.

- Luo, Wei, Maimuna S Majumder, Dianbo Liu, Canelle Poirier, Kenneth D Mandl, Marc Lipsitch, and Mauricio Santillana. 2020. "The Role of Absolute Humidity on Transmission Rates of the COVID-19 Outbreak." MedRxiv, 7. https://doi.org/10.1101/2020.02.12.20022467.

- https://home.iitd.ac.in/research-pracriti.php

Papers suggest important predictors, data sources

# How do you go about choosing a Project for the course?

- Case studies in inventory management, epidemic detection, design of public spaces, smart cities, mobility, thermal comfort, simulation based optimization, twitter data analysis.

- AI assisted health care (Eric Schmidt) and wellness (Quantified Self)

- Data science for COVID-19, post COVID-19 India

- [Responsible AI for Social Empowerment (RAISE 2020)](), [National Strategy for AI]() #AIforAll

- Problems you are motivated to solve - talk to users/experts, Journals in data science, TED talks, [Kaggle datasets]()

- Read research papers to find authentic data sources, writing a research paper.

- Groups of three or four (diverse groups preferably)

Project Proposal submission

- Describe why would you like to work on this problem (your motivation), what will it do and who will use it. Please add references to your background research.

- Describe your approach, mention challenges that you foresee, skills used, timeline. Provide a schematic of your final project idea(s)

- Your project should utilize the skills learnt in the class (in a synergistic manner) i.e. design thinking, data preprocessing and visualization, machine learning, digital prototyping and statistical methods in design. Please discuss with the instructor about special cases.

- Please work in teams of three or four but please make sure that everyone in the team learns the skills used in the project. It should be a complete project. It should connect to the real world. Rigor is important.

- Please mention the names of the team members in your project proposal.

- Special aspects such as creativity, innovation, impactful, etc.

Gantt Chart – Slide Template
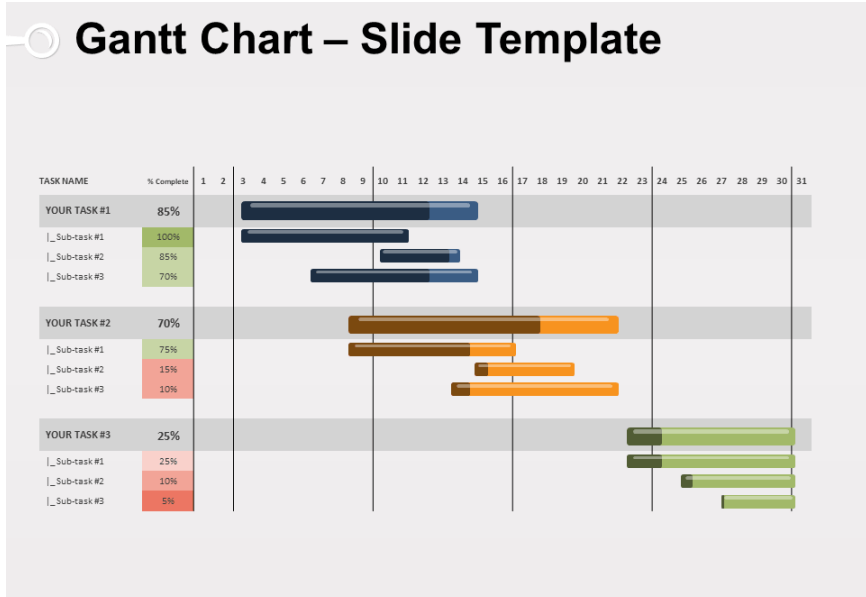
www.presentationgo.com

Critical Path = 4 Days
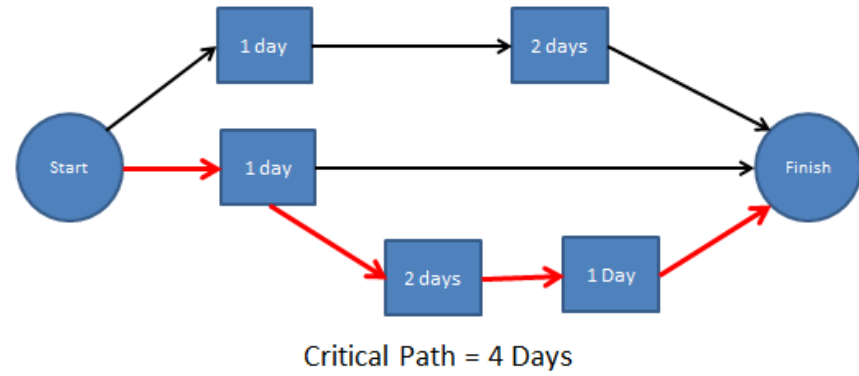
Critical Path Method

Project Management tips

- Fab Academy Notes Video (29:40-39:40)
- Spiral Development
- Demand side vs. Supply side Time Mgmt.
- Bottom up vs. Top down debugging
- Document as you work

Assignment

- Assignment 1: Project Proposal submission due on 23rd October

Announcements

- Assignments are about the skills learnt in the class
- We would give you a chance to resubmit your assignment for re-evaluation once after we evaluate your assignment.