Crowd-sourced Machine Learning Models for City-Scale Analytics: The Great Energy Predictor Competition 2019

Building Energy Efficiency and Sustainability in the Tropics

Clayton Miller

Asst. Professor at the National University of Singapore, School of Design and Environment
Theme D Co-Leader

National Research Foundation Singapore | CREATE Campus for Research Excellence And Technological Enterprise | BEARS Berkeley Education Alliance for Research in Singapore Limited | Berkeley University of California | Nanyang Technological University | NUS National University of Singapore

Building and Urban Data Science (BUDS) Group

buds lab

building and urban data science

BUDS Lab is a scientific research group that leverages data sources from the built and urban environments to improve the energy efficiency and conservation, comfort, safety and satisfaction of humans.

Check us out on Twitter and GitHub and subscribe to the email list

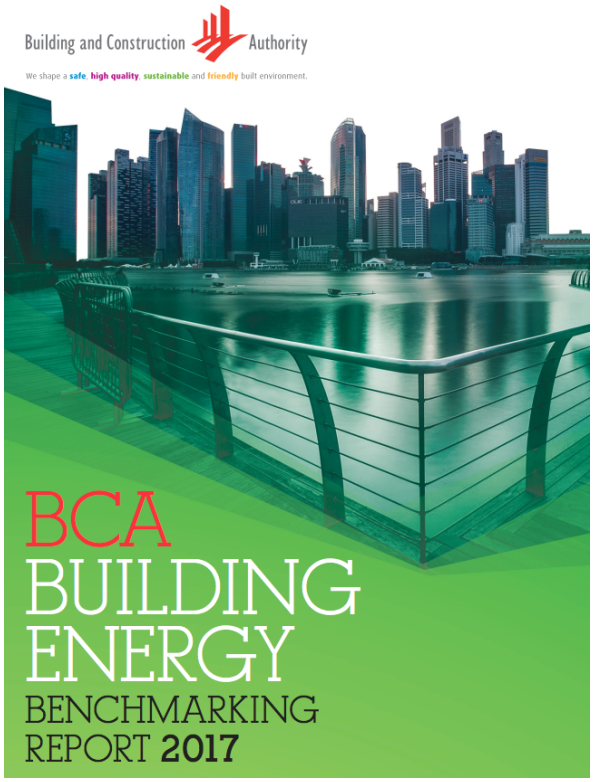
http://www.budslab.org

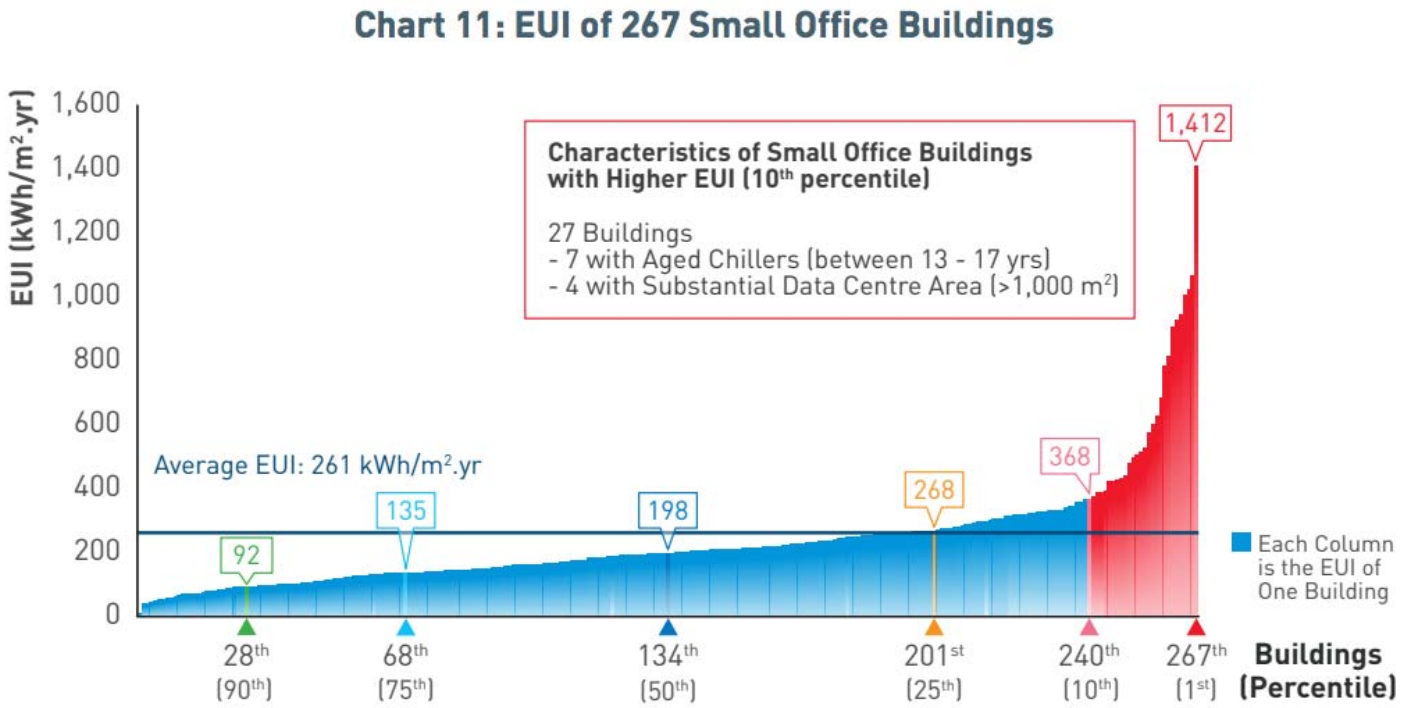






Thrust D Mission - What can we do about “bad buildings”?



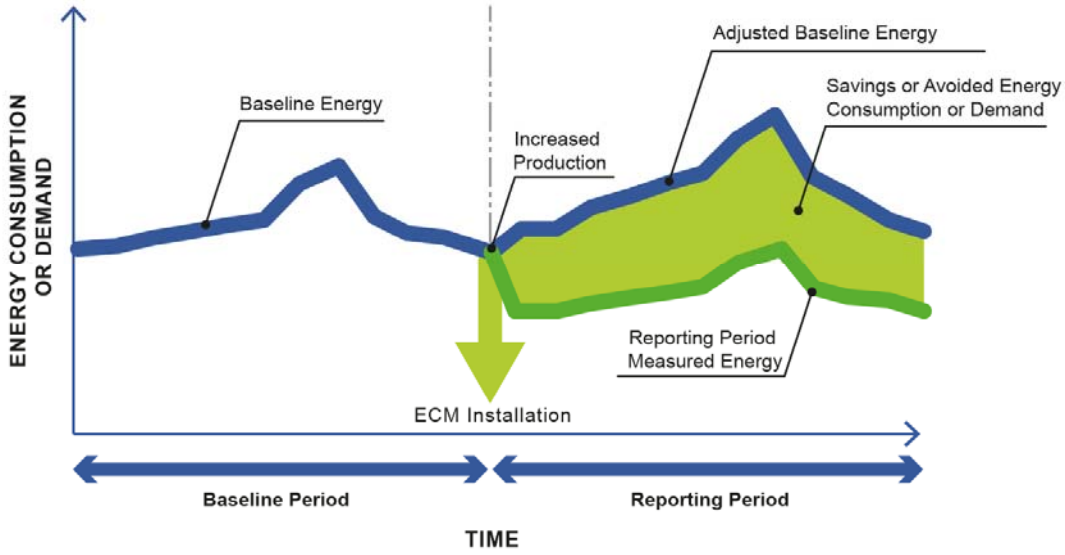


Which energy savings measures are best suited for the poor performing buildings?

How can we predict the potential magnitude of energy savings?

Machine Learning for Building Performance Prediction

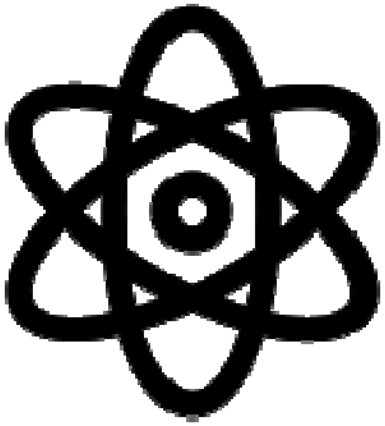
"A wide range of new techniques is now being applied to the analysis problems involved with predicting the future behavior of HVAC systems and deducing properties of these systems."



Graphic from: IPMVP, EVO

Every Research Community is Developing Rapidly

"Similar problems arise in most observational disciplines, including physics, biology, and economics."



There is an explosion of new techniques!

"New tools, such as genetic algorithms, simulated annealing, the use of connectionist models for forecasting and tree-based classifiers or the extraction of parameters of nonlinear systems with time-delay embedding, promise to provide results that are unobtainable with more traditional techniques."

Comparison of Techniques is a Major Challenge

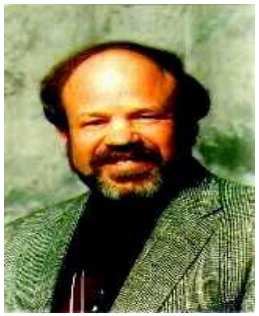
"Unfortunately, the realization and evaluation of this promise has been hampered by the difficulty of making rigorous comparisons between competing techniques, particularly ones that come from different disciplines."

Building Performance Machine Learning History Lesson

These are not my words.

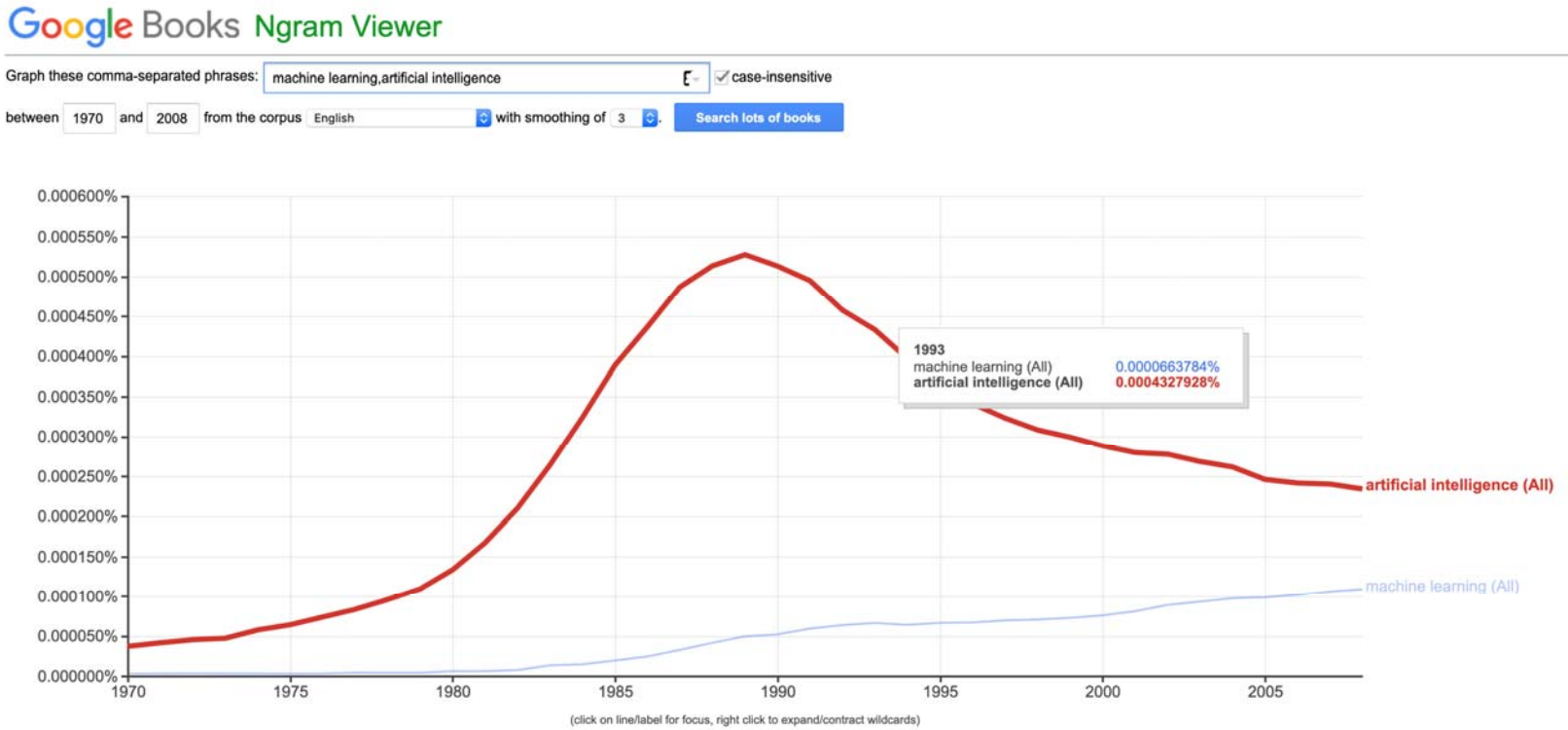
And they're not from 2019.

Those quotes were from an a machine learning competition announcement written in June 1993 by Jeff Haberl and Jan Kreider



Machine Learning was the
the focus of a 1993 and 1994 competition called
The Great Energy Predictor Shootout I and II sponsored by
ASHRAE's Technical Committees 4.7 and 1.5

This competition was at the forefront of AI/ML



The Great Energy Predictor Shootouts were in the first wave of AI/ML and were likely part of the first comparative competitions of its type

… and things were a little more challenging back then…

"THE GREAT ENERGY PREDICTOR SHOOTOUT" - THE FIRST BUILDING DATA ANALYSIS AND PREDICTION COMPETITION

"ACCESSING THE DATA:

The data are available on disks (5.25-in size) in ASCII, IBM-PC format. To receive the data, send a self-addressed 9 x 12 in. envelope, with a $2.90 priority mail stamp affixed, to: …

…Instructions on submitting a return disk with the analysis of the data will be included in a README file on the data disk."

- Predictor Shootout I Announcement from 1993

The Predictor Shootout I Objective #1

"A.dat (approximately 3,000 points)

This is a time record of hourly chilled water, hot water and whole building electricity usage for a four-month period in an institutional building. Weather data and a time stamp are also included. The hourly values of usage of these three energy forms is to be predicted for the two following months. The testing set consists of the two months following the four-month period."

Train/Test Weather Data

Training Energy – CHW, HW, and Hourly Elec	Test Energy
4 Months	2 Months

Evaluation Metrics:

Coefficient of Variation, CV(RMSE): $$CV(\%) = \frac{\sqrt{\frac{\sum_{i=1}^{n}(y_{predict,i} - y_{data,i})^2}{n-p}}}{\bar{y}_{data}} x100$$

Mean Bias Error, MBE: $$MBE(\%) = \frac{\frac{\sum_{i=1}^{n}(y_{predict,i} - y_{data,i})}{n-p}}{\bar{y}_{data}} x100$$

Shootout I - The Results!

Kreider, J, and Haberl, J. 1994. "Predicting Hourly Energy Usage: The Results of the 1993 Great Energy Predictor Shootout Identify the Most Accurate Method for Making Hourly Energy use Predictions", *ASHRAE Journal*, accepted for publication, (June).

"150 entrants requested data sets for which they were to make specific challenging analyses and predictions using their empirical tool of choice"

"…connectionist methods excelled in the analytical tasks when used either by experts or novices. The six identified winners of the competition used different methods, all within the broad definition of connectionist approaches."

The Great Energy Predictor Shootout II

ESL-TR-94/07-01 ESL Technical Report

INSTRUCTIONS - "THE GREAT BUILDING ENERGY PREDICTOR SHOOTOUT II: MEASURING RETROFIT ENERGY SAVINGS"

I. OVERALL CONTEST PHILOSOPHY

Overview

Based on the overwhelming response to the first Building Energy Predictor Shootout a second predictor shootout has been developed to again compare how well different empirical models predict building energy data from several new data sets *and* compare how those models can be used to calculate energy conservation retrofit savings. ASHRAE's TC 1.5 and TC 4.7 have authorized a "Building Energy Predictor Shootout II: Measuring Retrofit Energy Savings" which is the focus of this competition.

The results of this friendly competition will be published in an ASHRAE Symposium. All able bodied building energy analysts are encouraged to participate. In order to facilitate this comparison before-after data and selected site description data from two carefully chosen buildings that have received retrofits as part of the Texas LoanSTAR program will be made available to the contestants and placed on the internet for public access along with instructions about how to participate.

Signs of technology adoption and progress…

The internet access to the data is as follows[2] (LoanSTAR's internet address is: 128.194.18.1):

First, login to the LoanSTAR FTP server (loanstar@tamu.edu) by typing:
"ftp loanstar.tamu.edu"

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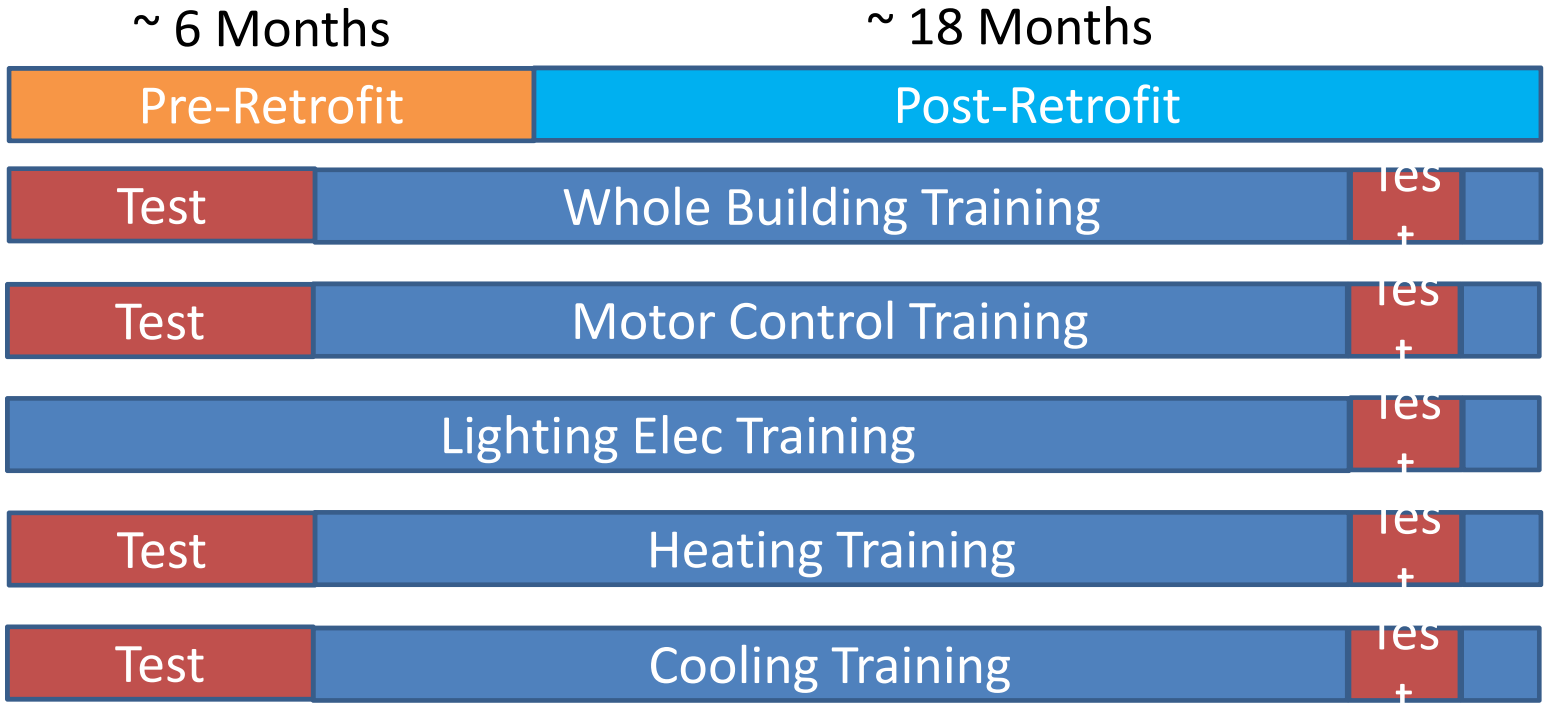
[2] We are also in the process of setting up a description of the competition on the World Wide Web through the ESL's homepage. This can be accessed via "http:/loanstar.tamu.edu/esl_home_page.html"

The Predictor Shootout II - Business Building Example



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Shootout II - The Results

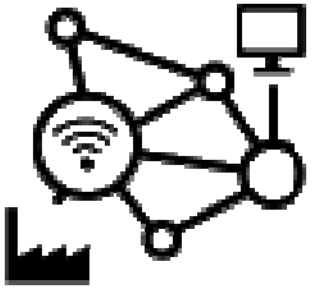
Haberl, J.S., and Thamilseran, S.. Great energy predictor shootout II: Measuring retrofit savings -- overview and discussion of results. United States: N. p., 1996. Web.

“The results from the contest show that neural networks again provide the most accurate model of a building’s energy use."

“However, in contrast to the first contest, the second contest`s results show that cleverly assembled statistical models also appear to be as accurate or, in some cases, more accurate than some of the neural network entries."

A lot has changed in 25 years!

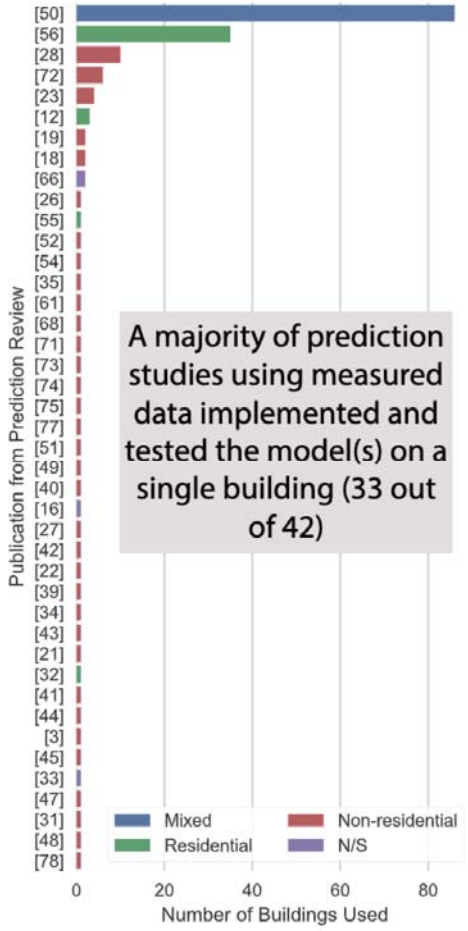
The Internet
Digitization
IoT
Data Science
Coding Skills
Smart devices



But we are still suffering from the exact same challenges

ML has HUGE potential and there are literally hundreds of new techniques applied to building energy prediction.

But generalizability is STILL a major issue. Most techniques applied on separate data sets and from single buildings (Amasyali, 2018)

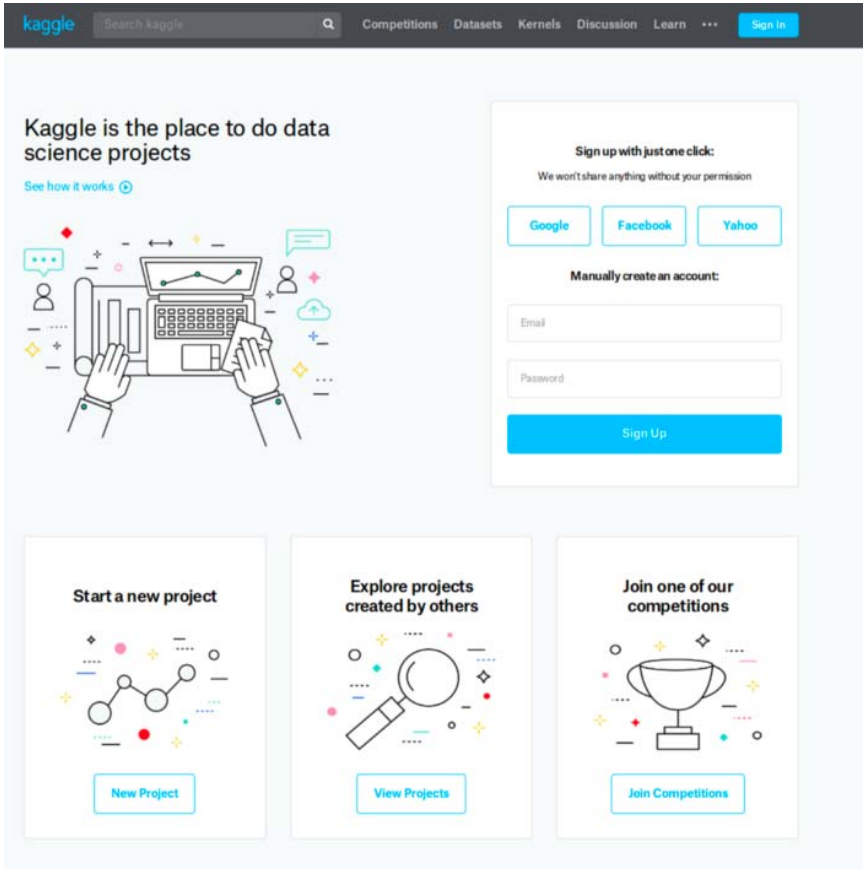


Machine Learning Competitions have come a long way

Several platforms host hundreds of competitions including several with $1 million in prize money

Kaggle Statistics

- In June 2017, Kaggle announced that it passed 1,000,000 registered users, or Kagglers.
- The community spans 194 countries. Kaggle competitions regularly attract over a thousand teams and individuals. Kaggle's community has thousands of public data sets and code snippets (called "kernels" on Kaggle).
- Many of these researchers publish papers in peer-reviewed journals based on their performance in Kaggle competitions.



Examples of Competitions on Kaggle

Two Sigma: Using News to Predict Stock Movements
Use news analytics to predict stock price performance
Featured · Kernels Competition · 2 months to go · news agencies, time series, finance, money

$100,000
2,927 teams

Microsoft Malware Prediction
Can you predict if a machine will soon be hit with malware?
Research · 2 months ago

$25,000
2,426 teams

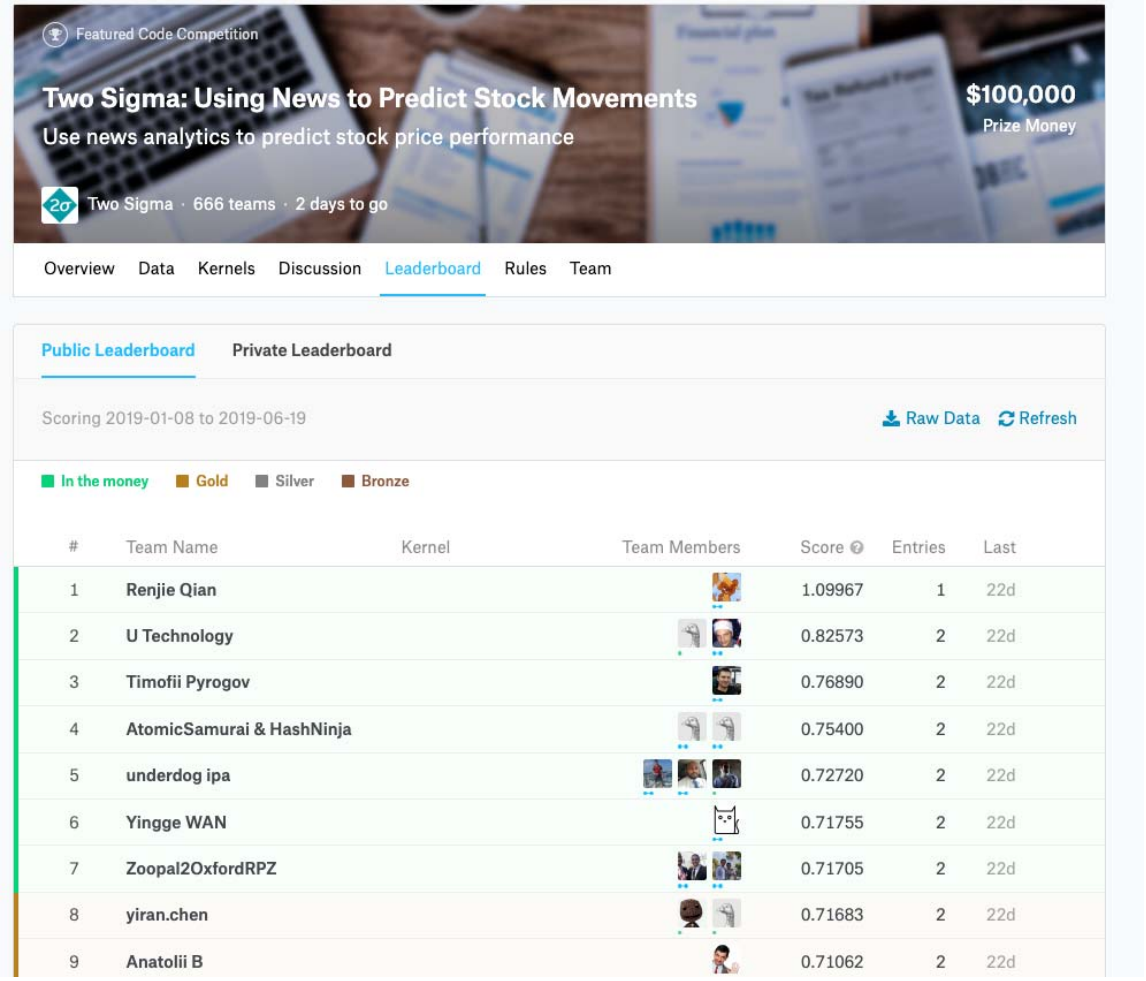
NFL Punt Analytics Competition
Analyze NFL game data and suggest rules to improve player safety during punt plays
Analytics · 5 months ago · american football, sports, safety, health

$80,000

The 2nd YouTube-8M Video Understanding Challenge
Can you create a constrained-size model to predict video labels?
Featured · 10 months ago · video data, object labeling

$25,000
312 teams

Real-time Competition Scoring and Discussion



- Contestants download training data and make predictions to be submitted to the platform
- They submission is instantly scored and they show up on a leader board
- The top scores at the end of the competition must open-source their technique to claim prize money

Great Predictor Competition 2019

Back to the basics of Shootout I Energy Prediction,
but with 10,000 times more data:

~3500 energy meters (elec., heating, cooling, steam)

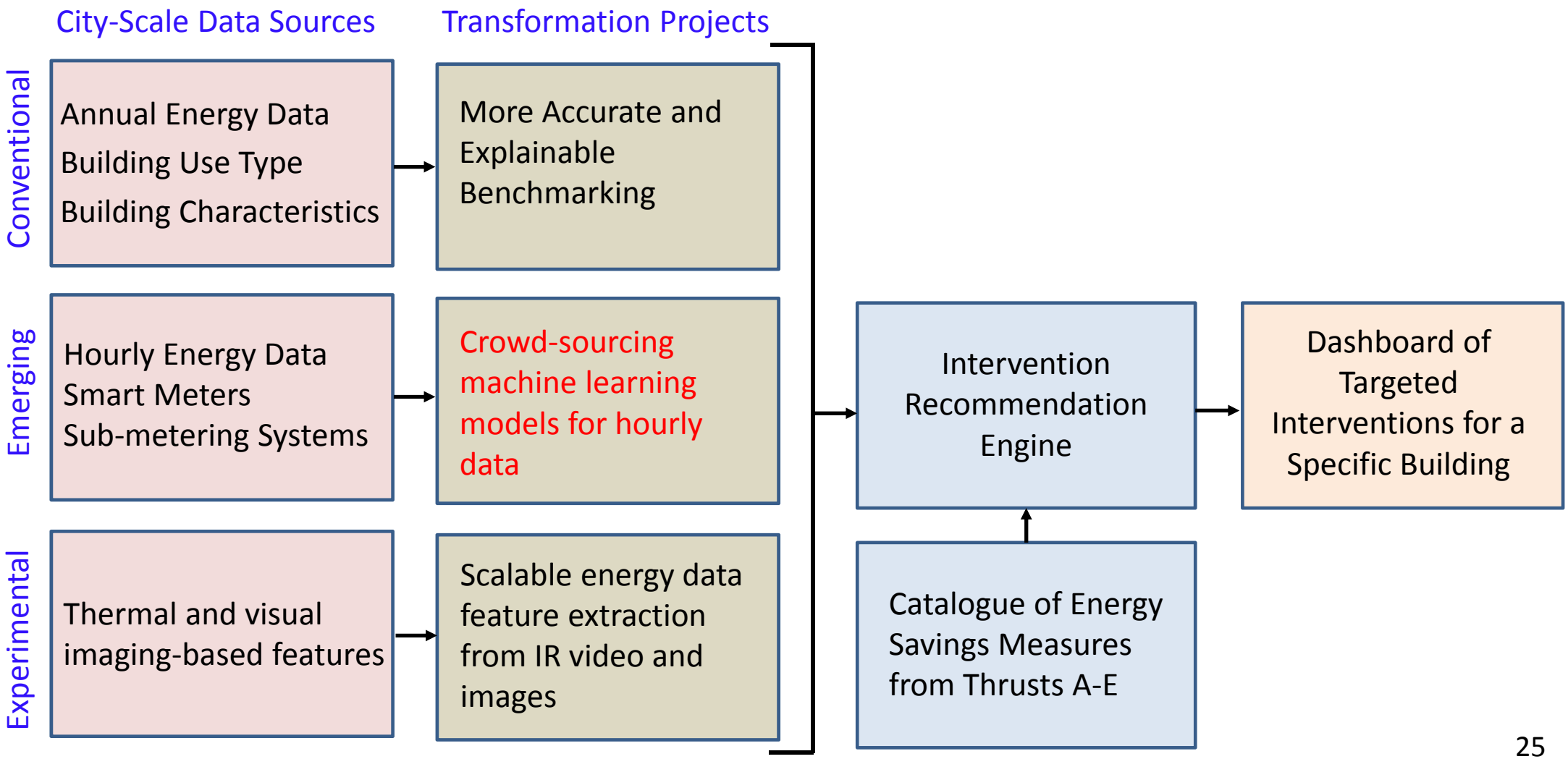
~1500 buildings

= ~ 30 million measurements

Great Predictor Competition 2019

- A diverse international technical team led by SBB2 Thrust D
- Data sets from dozens of sources in almost every ASHRAE climate zone
- Projected competition is Sept.-Dec. 2019 with winners announced in Orlando 2020
- Plans for winners to showcase their techniques at ASHRAE Summer Meeting 2020
- Potential Special Issue of ASHRAE Journal or Science & Technology for the Built Environment

A Platform for Targeting Buildings for Specific Interventions



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