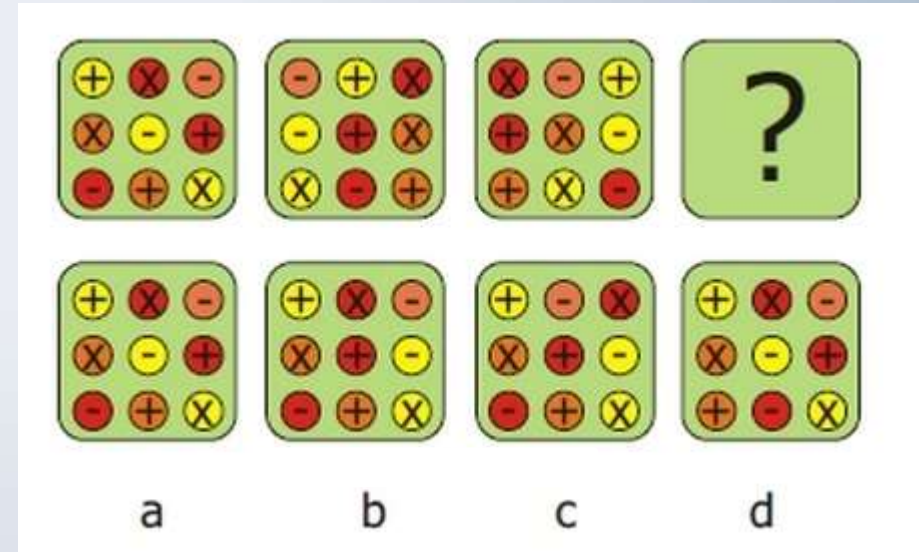


What is this Machine Learning Stuff and How Can I Use It?

MACHINE LEARNING

- In it's simplest form Machine learning is pattern detection
- What comes next?

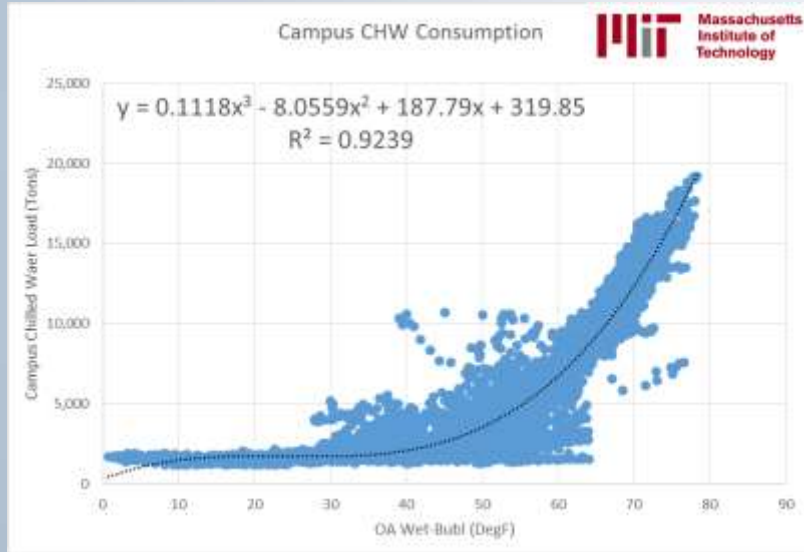


WHY DO WE NEED MACHINE LEARNING?

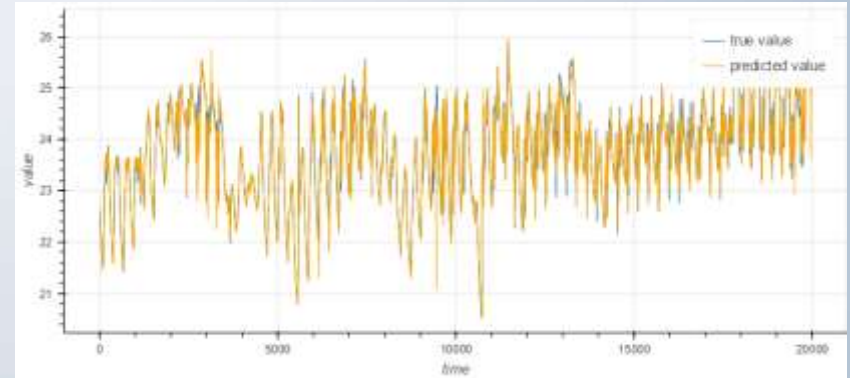
- **We have too much data and are breaking excel**
- **Most data relationships are much more complicated than 2-D.**

MACHINE LEARNING VS LINEAR REGRESSION

Traditional non-linear regression analysis allows 2D M&V normalization



Machine learning allows for limitless dimensional normalization and prediction



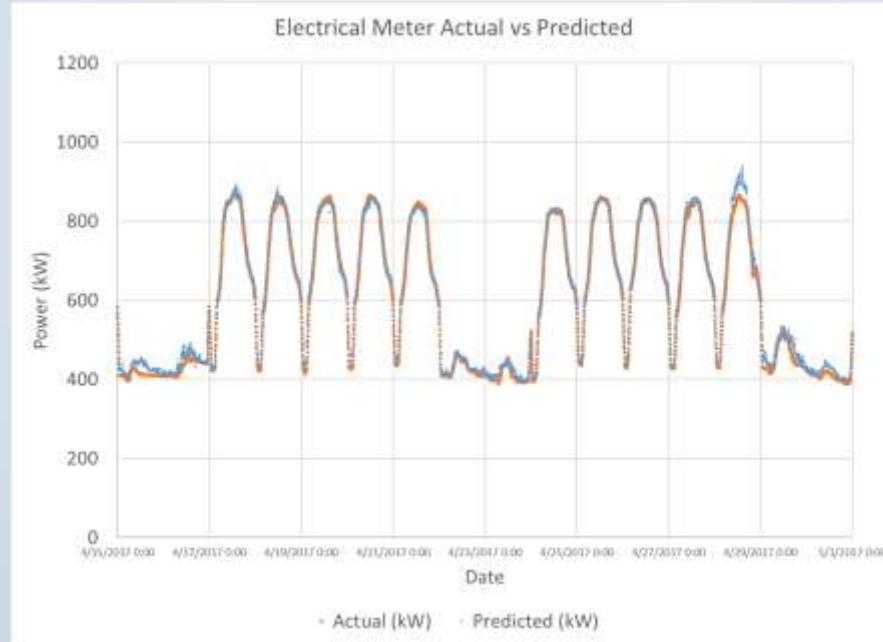
MULTIDIMENSIONAL DATA RELATIONSHIPS

- **EXAMPLE: Building Chilled Water Load**
 - OA Wetbulb
 - Time of Day
 - Day of Week (weekend/weekday)
 - Month of year
 - Holiday and Class Schedule
 - Solar Angle
 - UV Index
- “My building is consuming 500 Tons right now, is that good or bad?”



MODEL ACCURACY AND SCORING

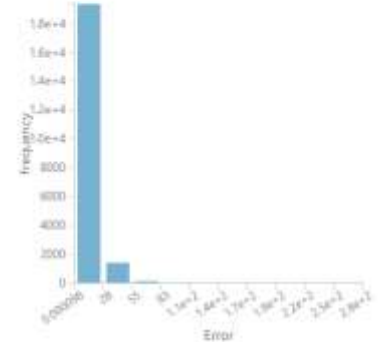
- Accuracy is “scored” based on a number of metrics
- R^2 is typically above 97%



Metrics

Mean Absolute Error	11.606773
Root Mean Squared Error	16.467189
Relative Absolute Error	0.072262
Relative Squared Error	0.008225
Coefficient of Determination	0.991775

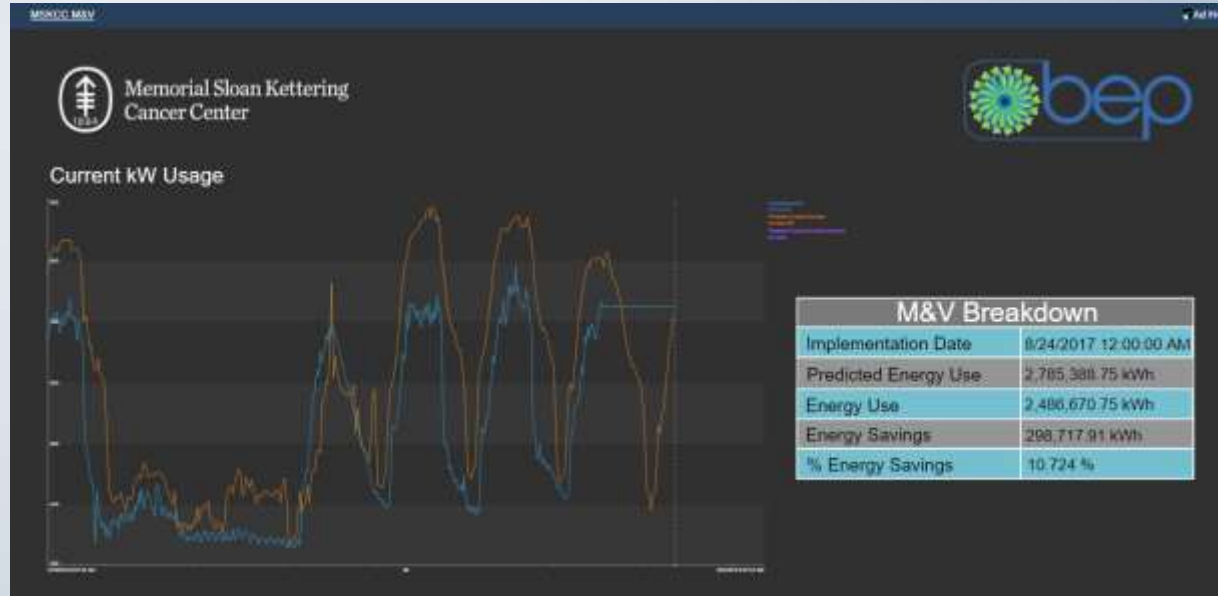
Error Histogram



WHAT ARE PRACTICAL APPLICATIONS OF MACHINE LEARNING?

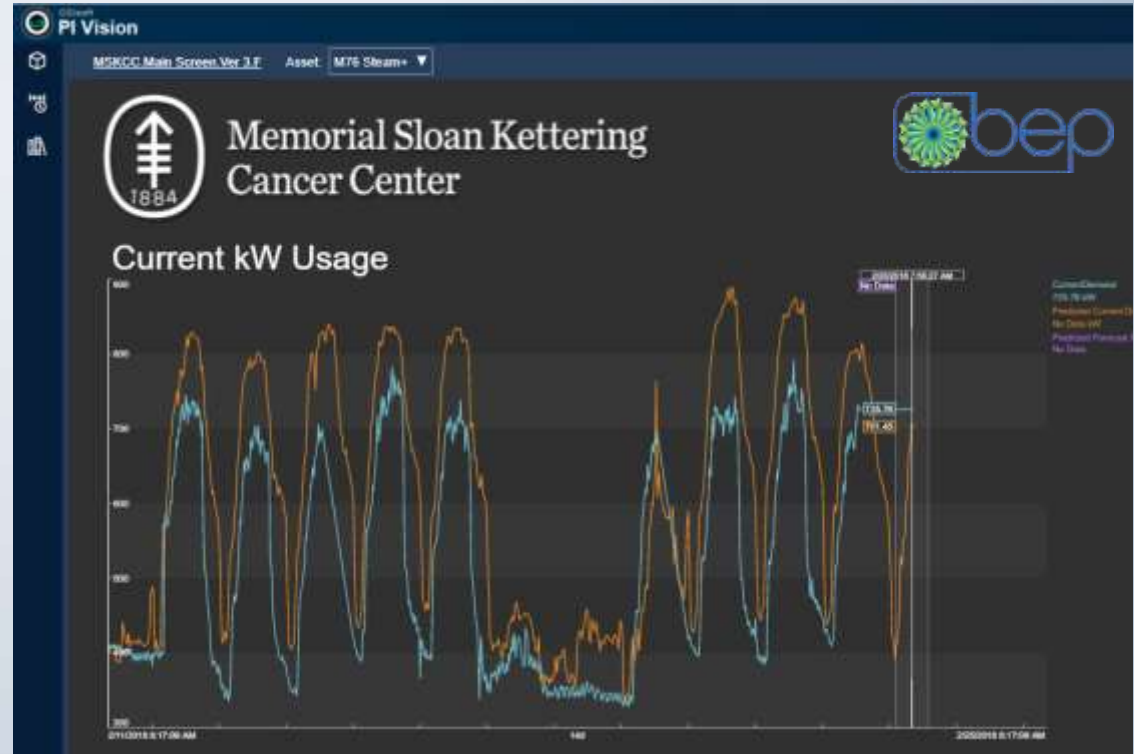
MEASUREMENT AND VERIFICATION

- “Live” M&V
- Train model “pre implementation”
- M&V with “post implementation”



FAULT DETECTION AT ENERGY METER LEVEL

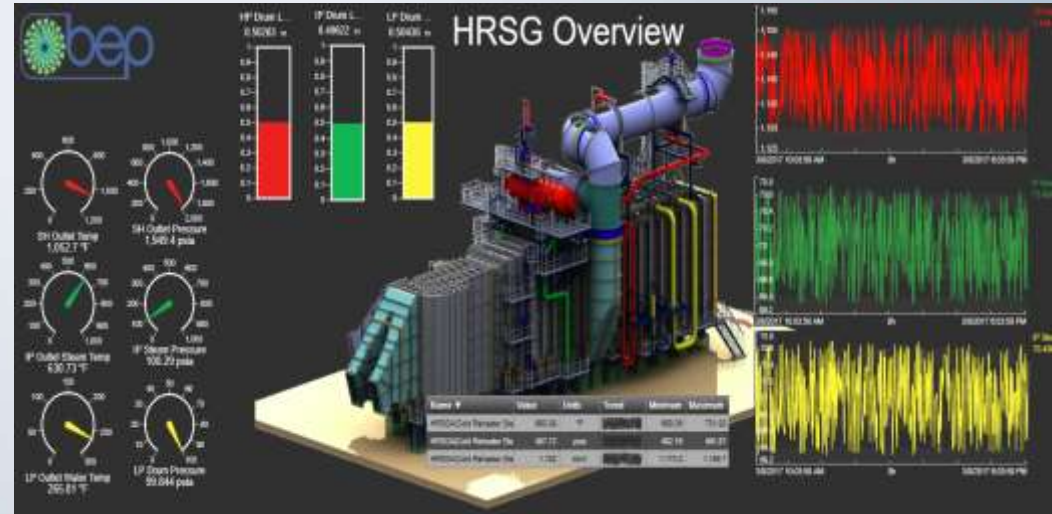
- When usage varies from predicted, trigger an alarm
- “Live building benchmarking”
 - Current kbtu/sf compared to predicted
- More macro than “rule based” fault detection



FAULT DETECTION AT SYSTEM LEVEL

- Predict component performance and “energy” alarm when component is not performing

- Component scheduling
- KW/Ton
- Supply temperatures
- Pressure differentials
- Endless possibilities



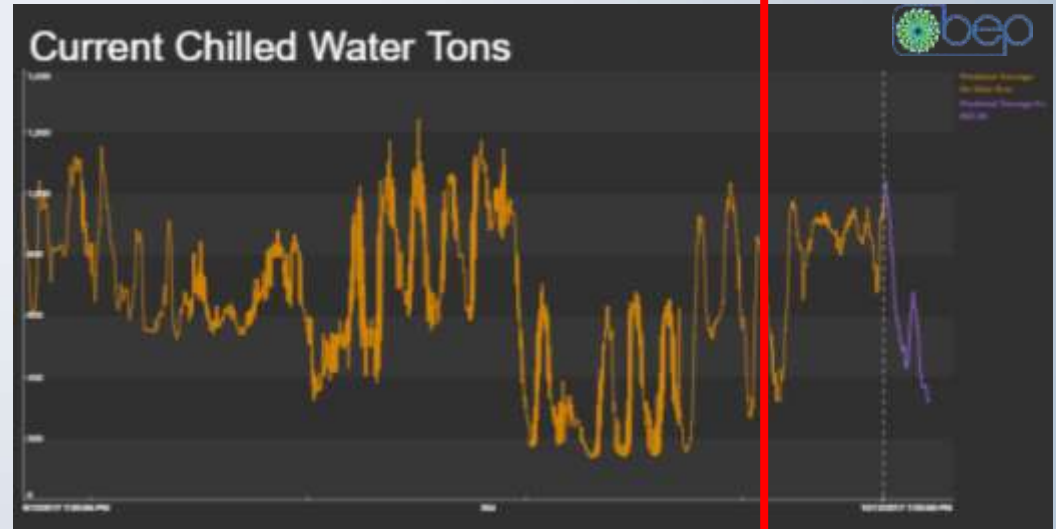
PRICE FORECASTING FOR TIME OF DAY ENERGY RATES

- **ConED historical time of use rates are published**



LOAD PROJECTING AND EQUIPMENT DISPATCHING

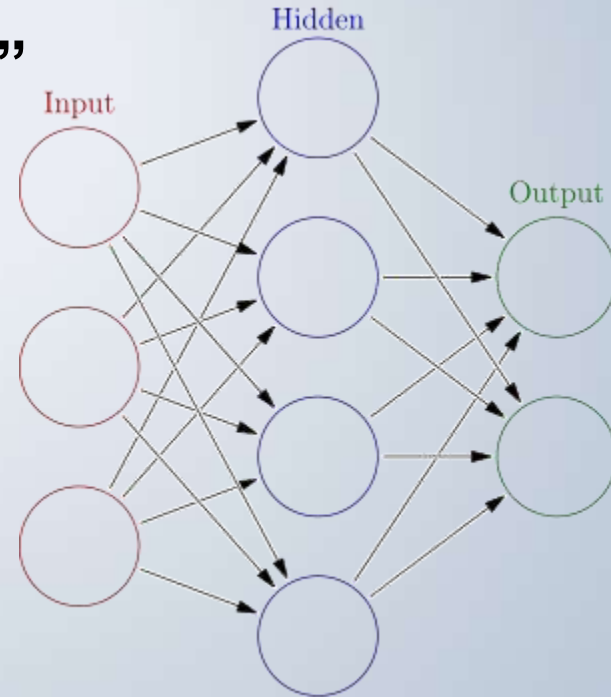
- 2 day ahead load prediction
- Weather forecast taken from NOAA
 - DB
 - WB
 - UV Index
- Upcoming holiday
- Calendar (time of day, day of week)



HOW DOES IT WORK?

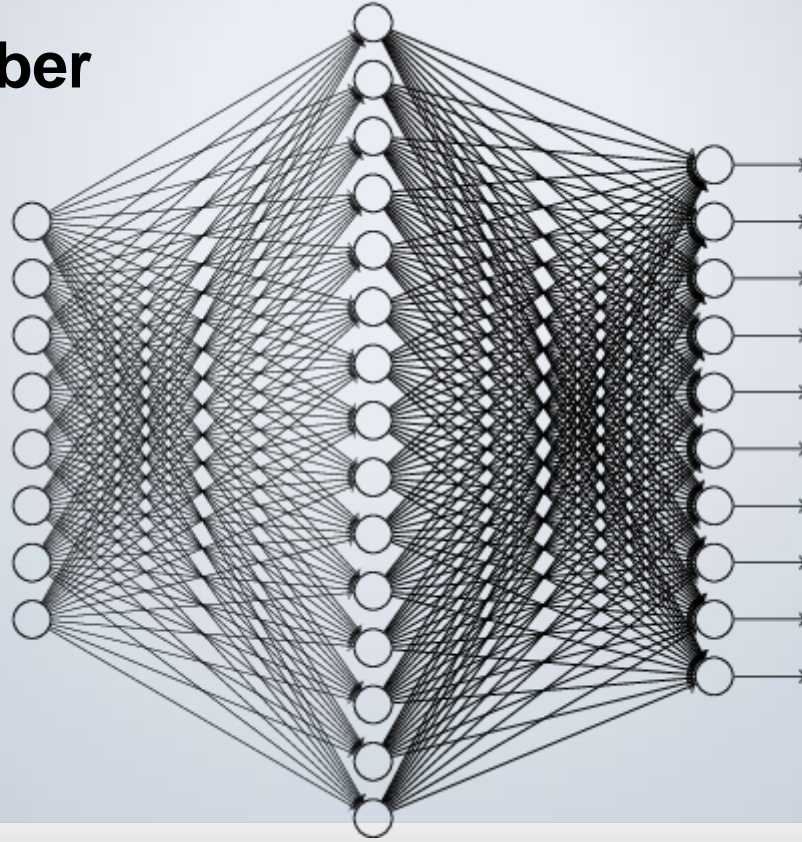
NEURAL NETWORKS: BASIC

- Input layer,
- Hidden layer (applies a “weight” to each input combination)
- Output layer

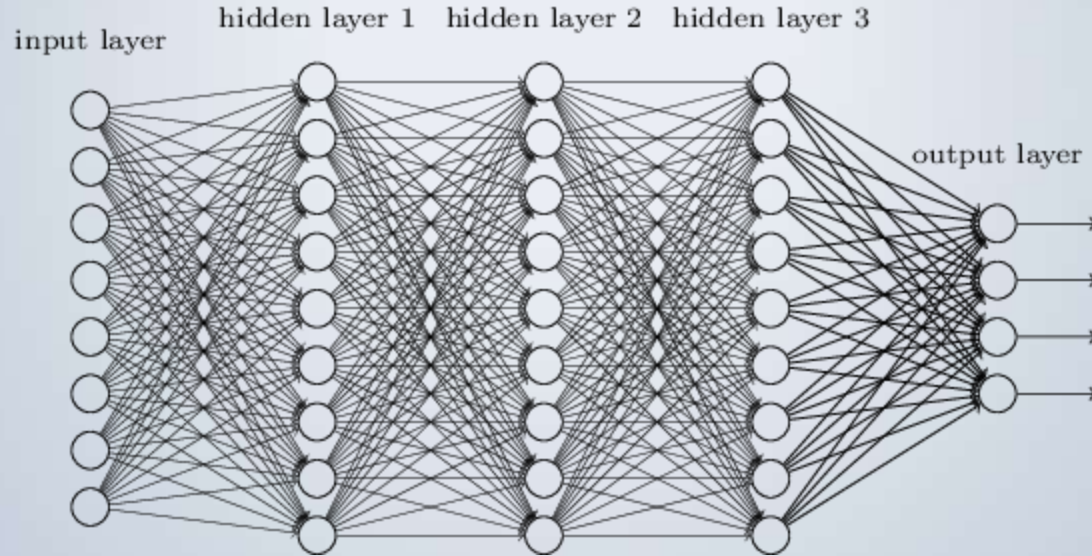


ADD DEPENDENT VARIABLES

- Limitless number of variables

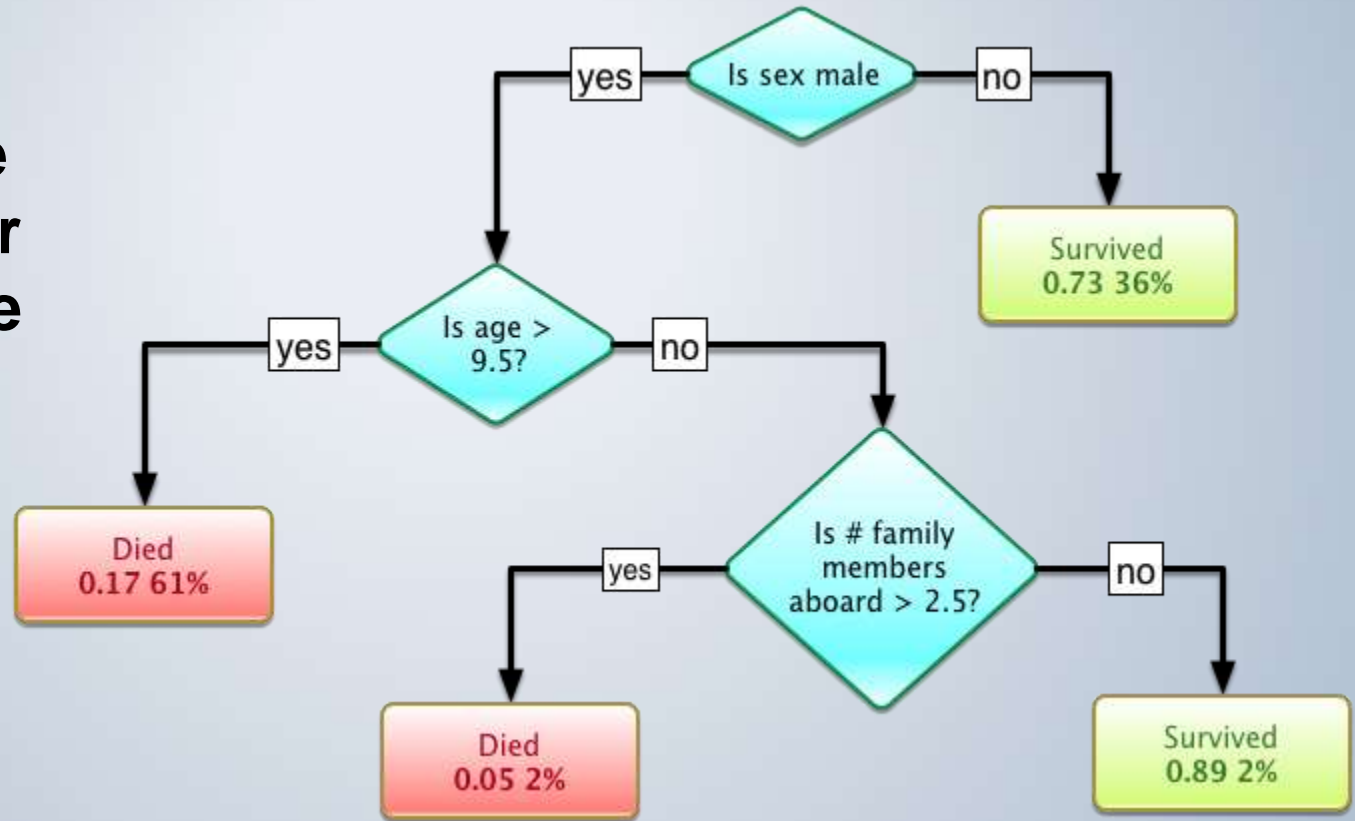


ADD ITERATIONS: DEEP LEARNING



DECISION TREES

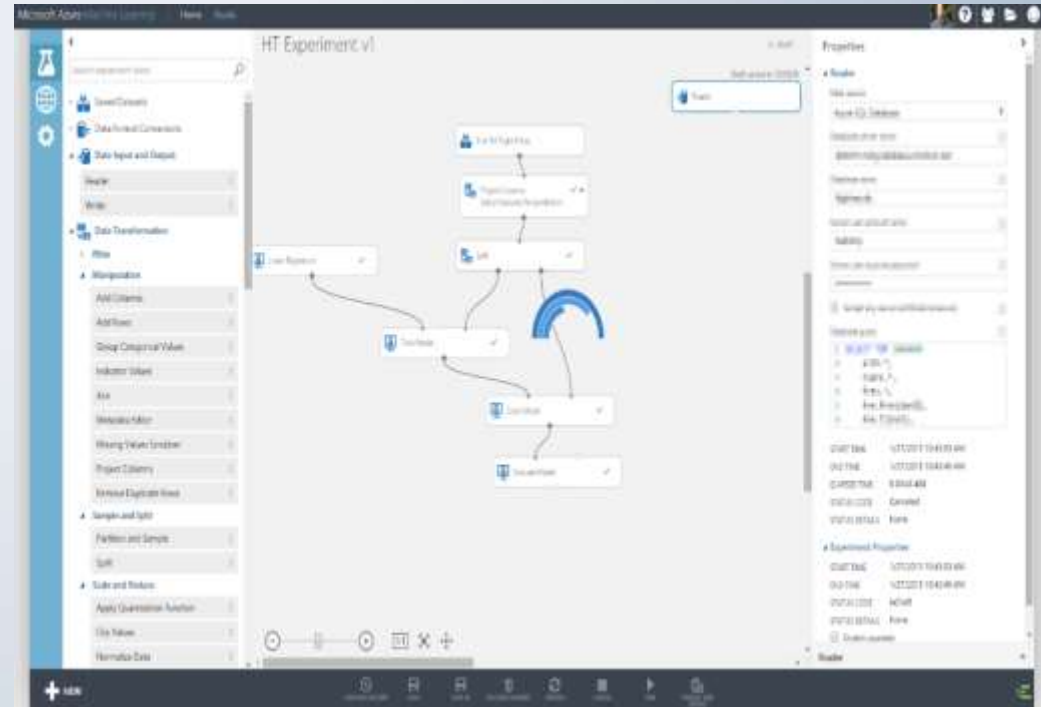
- “Boosted” decision tree adds an error to each stage



HOW CAN YOU USE IT?

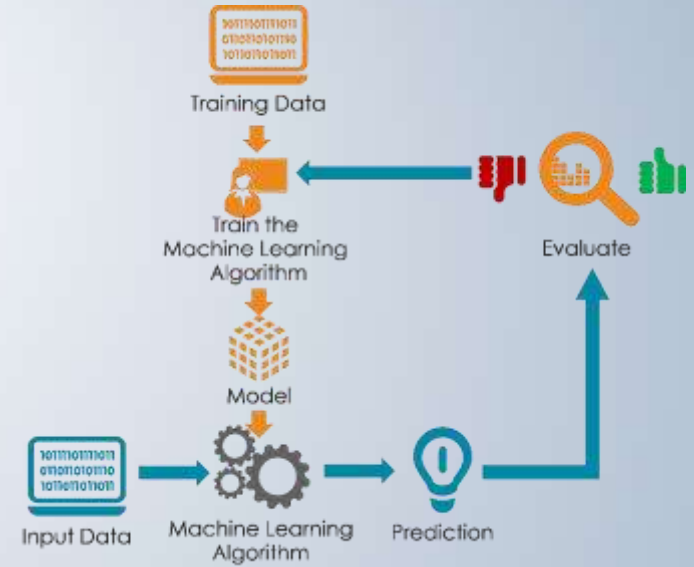
HOW CAN YOU USE IT?

- Hire data scientist
- Use cloud-based tools
 - Microsoft Azure
 - Amazon ML
 - Google Tensorflow
 - IBM Bluemix



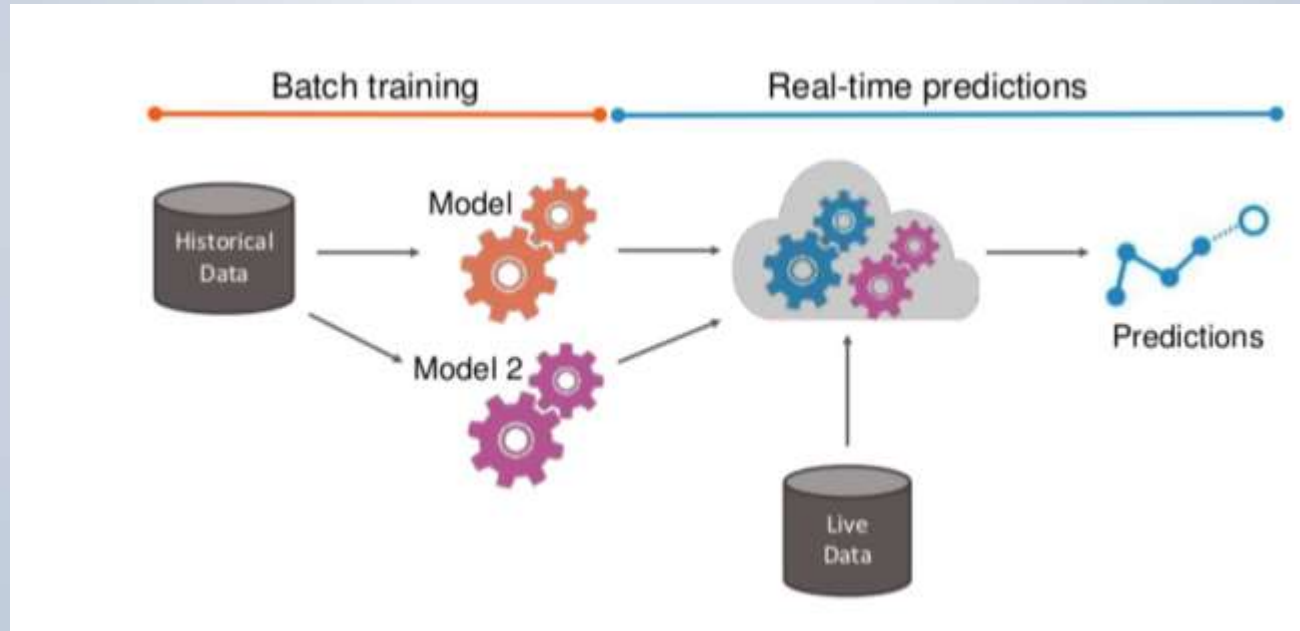
MACHINE LEARNING MODEL TRAINING PROCESS

- **Step 1) clean data.....this is the hardest part**
- **Step 2) Divide data into 2 sets**
 - **80% to train model**
 - **20% to score model**
- **Step 3) Tune the model (hyperparameter tuning)**
- **Step 3) Use model to predict future outcomes**



LIVE DATA FOR LIVE PREDICTIONS

- The greatest value is with doing this with live data



DATA HISTORIAN AS MACHINE LEARNING GATEWAY

- Integrate with data historians to empower it with machine learning



Wonderware
Historian
Publisher

Thank You

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