

Future directions of AI in the Enterprise

Using automation to extract meaning from data

Michael Schmidt, Ph.D.

About me

- Cornell University, Ph.D. CCSL Lab
- Founded Nutonian in 2011
- Eureqa = AI Software, >50,000 users
- Cited in > 500 medical, scientific and research advances

"Computer Program Discovers Laws of Physics"

-New York Times



Schmidt M., Lipson H. (2009) "Distilling Free-Form Natural Laws from Experimental Data," Science, Vol. 324, no. 5923, pp. 81 - 85.



$y = 0.02 \ x \cos(4 \ x) + 1/(1 + \exp(-4 \ x))$



SP Routing - Private Route-calcRoute -- ATL - availability SP Routing - Private Route-calcRoute - ATL - latency SP Routing - Private Route-getRoute - ATL - availability SP Routing - Private Route-getRoute -- ATL - latency SP Routing - Private Route-calcRoute.-ATL - availability SP Routing - Private Route-calcRoute.-ATL - latency SP Routing - Private Route-getRoute -ATL - availability SP Routing - Private Route-getRoute -ATL - latency SP Routing - Private Route-calcRoute -ATL - availability

Tiles - Global - ATL latency MSP MRS - Private - Map Tiles - Global - ATL availability MSP MRS - Private - Map Tiles - Global - ATL latency MSP MRS - Private -Satellite Tiles - Global - ATL availability MSP MRS - Private -Satellite Tiles - Global - ATL latency MSP Forward Geocoder -Private - Address - Global -ATL - availability MSP Forward Geocoder -Private - Address - Global -ATL - latency MSP Forward Geocoder -Private - City - Global - ATL availability MSP Forward Geocoder -Private - City - Global - ATL - latency MSP LBSP Traffic - Private -Traffic Tiles - Global - ATL availability

MSP MRS - Private -Satellite Tiles - Local - ATL availability MSP MRS - Private -Satellite Tiles - Local - ATL latency MSP Forward Geocoder -Private - Address - Local -ATL - availability MSP Forward Geocoder -Private - Address - Local -ATL - latency MSP Forward Geocoder -Private - City - Local - ATL availability MSP Forward Geocoder -Private - City - Local - ATL latency MSP LBSP Traffic - Private -Traffic Tiles - Local - ATL availability MSP LBSP Traffic - Private -Traffic Tiles - Local - ATL latency MSP MRS - Private - Hybrid Tiles - Global - SIN availability MSP MRS - Private - Hybrid Tiles - Global - SIN - latency

SIN - availability MSP Forward Geocoder -Private - Address - Global -SIN - latency MSP Forward Geocoder -Private - City - Global - SIN availability MSP Forward Geocoder -Private - City - Global - SIN latency MSP LBSP Traffic - Private -Traffic Tiles - Global - SIN availability MSP LBSP Traffic - Private -Traffic Tiles - Global - SIN latency MSP MRS - Private - Hybrid Tiles - Local - SIN availability MSP MRS - Private - Hybrid Tiles - Local - SIN - latency MSP MRS - Private - Map Tiles - Local - SIN availability MSP MRS - Private - Map Tiles - Local - SIN - latency MSP MRS - Private -Satellite Tiles - Local - SIN availability

Private - City - Local - SIN latency MSP LBSP Traffic - Private -Traffic Tiles - Local - SIN availability MSP LBSP Traffic - Private -Traffic Tiles - Local - SIN latency MSP LBSP Routing - Private - Long Route-calcRoute -Global - SIN - availability MSP LBSP Routing - Private - Long Route-calcRoute -Global - SIN - latency MSP LBSP Routing - Private - Long Route-getRoute -Global - SIN - availability MSP LBSP Routing - Private - Long Route-getRoute -Global - SIN - latency MSP LBSP Routing - Private - Short Route-calcRoute -Global - SIN - availability MSP LBSP Routing - Private - Short Route-calcRoute -Global - SIN - latency MSP LBSP Routing - Private - Short Route-getRoute -Global - SIN - availability

- Long Route-getRoute -Local - SIN - latency MSP LBSP Routing - Private - Short Route-calcRoute -Local - SIN - availability MSP LBSP Routing - Private - Short Route-calcRoute -Local - SIN - latency MSP LBSP Routing - Private - Short Route-getRoute -Local - SIN - availability MSP LBSP Routing - Private - Short Route-getRoute -Local - SIN - latency MSP MRS - Private - Hybrid Tiles - Global - LHR availability MSP MRS - Private - Hybrid Tiles - Global - LHR latency MSP MRS - Private - Map Tiles - Global - LHR availability MSP MRS - Private - Map Tiles - Global - LHR latency MSP MRS - Private -Satellite Tiles - Global - LHR availability

Private - City - Global - LHR latency MSP LBSP Traffic - Private -Traffic Tiles - Global - LHR availability MSP LBSP Traffic - Private -Traffic Tiles - Global - I HR latency MSP MRS - Private - Hybrid Tiles - Local - LHR availability MSP MRS - Private - Hybrid Tiles - Local - LHR - latency MSP MRS - Private - Map Tiles - Local - LHR availability MSP MRS - Private - Map Tiles - Local - LHR - latency MSP MRS - Private -Satellite Tiles - Local - LHR availability MSP MRS - Private -Satellite Tiles - Local - LHR latency MSP Forward Geocoder -Private - Address - Local -LHR - availability

SP Routing - Private Route-getRoute - NUQ - latency SP Routing - Private Route-calcRoute.-NUQ - availability SP Routing - Private Route-calcRoute -NUQ - latency SP Routing - Private Route-calcRoute -NUQ - availability SP Routing - Private Route-calcRoute -NUQ - latency SP Routing - Private Route-getRoute -NUQ - availability SP Routing - Private Route-getRoute -NUQ - latency RS - Private - Hybrid Global - NUQ ility RS - Private - Hybrid Global - NUO -

MSP Forward Geocoder -Private - Address - Global -NUQ - latency MSP Forward Geocoder -Private - City - Global -NUQ - availability MSP Forward Geocoder -Private - City - Global -NUQ - latency MSP LBSP Traffic - Private -Traffic Tiles - Global - NUQ availability MSP LBSP Traffic - Private -Traffic Tiles - Global - NUQ - latency MSP MRS - Private - Hybrid Tiles - Local - NUQ availability MSP MRS - Private - Hybrid Tiles - Local - NUQ - latency MSP MRS - Private - Map Tiles - Local - NUQ availability MSP MRS - Private - Map Tiles - Local - NUQ - latency MSP MRS - Private -

MSP Forward Geocoder -Private - City - Local - NUQ - latency MSP LBSP Traffic - Private -Traffic Tiles - Local - NUQ availability MSP LBSP Traffic - Private -Traffic Tiles - Local - NUQ latency MSP LBSP Routing - Private - Long Route-getRoute -Local - NUQ - availability MSP LBSP Routing - Private - Long Route-getRoute -Local - NUQ - latency MSP Reverse Geocoder -Private - City - Global - ATL availability MSP Reverse Geocoder -Private - City - Global - ATL - latency MSP Reverse Geocoder -Private - City - Global - LHR availability MSP Reverse Geocoder -Private - City - Global - LHR

MSP Reverse Geocoder -Private - City - Local - ATL latency MSP Reverse Geocoder -Private - City - Local - LHR availability MSP Reverse Geocoder -Private - City - Local - LHR latency MSP Reverse Geocoder -Private - City - Local - NUQ availability MSP Reverse Geocoder -Private - City - Local - NUQ - latency MSP Reverse Geocoder -Private - City - Local - SIN availability MSP Reverse Geocoder -Private - City - Local - SIN latency MSP Forward Geocoder -Private - Address - Global -SYD - availability MSP Forward Geocoder -Private - Address - Global -

MSP Reverse Geocoder -Private - City - Global - SYD latency MSP LBSP Routing - Private - Long Route-calcRoute -Global - SYD - availability MSP LBSP Routing - Private - Long Route-calcRoute -Global - SYD - latency MSP LBSP Routing - Private - Long Route-getRoute -Global - SYD - availability MSP LBSP Routing - Private - Long Route-getRoute -Global - SYD - latency MSP MRS - Private - Map Tiles - Global - SYD availability MSP MRS - Private - Map Tiles - Global - SYD latency MSP MRS - Private -Satellite Tiles - Global - SYD availability MSP MRS - Private -Satellite Tiles - Global - SYD

MSP Forward Geocoder -Private - Address - Local -SYD - latency MSP Forward Geocoder -Private - City - Local - SYD availability MSP Forward Geocoder -Private - City - Local - SYD latency MSP MRS - Private - Hybrid Tiles - Local - SYD availability MSP MRS - Private - Hybrid Tiles - Local - SYD - latency MSP MRS - Private - Map Tiles - Local - SYD availability MSP MRS - Private - Map Tiles - Local - SYD - latency MSP MRS - Private -Satellite Tiles - Local - SYD availability MSP MRS - Private -Satellite Tiles - Local - SYD latency MSP Reverse Geocoder -

MSP LBSP Routing - Private - Long Route-getRoute -Local - SYD - latency MSP LBSP Routing - Private - Short Route-calcRoute -Local - SYD - availability MSP LBSP Routing - Private - Short Route-calcRoute -Local - SYD - latency MSP LBSP Routing - Private - Short Route-getRoute -Local - SYD - availability MSP LBSP Routing - Private - Short Route-getRoute -Local - SYD - latency MSP LBSP Traffic - Private Traffic Tiles - Local - SYD availability MSP LBSP Traffic - Private -Traffic Tiles - Local - SYD latency MSP LBSP Routing - Private - Short Route-calcRoute -Global - SYD - availability MSP LBSP Routing - Private - Short Route-calcRoute -



 $a_2 = v_1^2 \sin(x_1 - x_2) - a_1 \cos(x_2 - x_1) - 9.8 \sin(x_2)$



2500

The world obeys mathematical relationships – from physics to business operations

Modern AI can deduce these hidden patterns automatically from data

Machine Intelligence

Test and Find Structure



Model search



The science under the hood





-101×

Robot Scientist

Algorithms distill laws of physics from chaotic systems (published in *Science* 2009)



Schmidt M., Lipson H. (2009) "Distilling Free-Form Natural Laws from Experimental Data," <u>Science</u>, Vol. 324, no. 5923, pp. 81 - 85.

Getting the right result



Massively Parallel

Computation tests billions of independent models on the data



• High latency -- no control flow dependencies

Machine intelligence in action

- Predict finish positions of the 2016 Kentucky Derby
- Expose relationships between running style, speed, and trainer record
- Predicted winner, and 4 out of top 5 horses
 - Winning Exacta (30:1 odds),
 - Winning Trifecta (87:1)
 - Winning Superfecta (542:1)
 - 1. Nyquist
 - 2. Gun Runner
 - 3. Exaggerator
 - 4. Creator
 - 5. Mohaymen

- Standardized live odds probability
- Speed over the past two races
- Post position
- Racing style
- Track conditions

http://performancegenetics.com/machine-learning-algorithm-crushed-kentucky-derby/

Example



Demand forecasting for pharmaceuticals

er <mark>eo</mark> a	Analyses / SKU Pricing & Forecasting - Q4 2015									
↑	 I Card Share 		C V	SHe	ealth					
?Q f₀	SKU Pricing & Forecasting - Q4 2015									
(x)	 Pricing summary for 100,810 SKUs 									
	Cost per claim Price volatility	у								
¢	Historically Currently Forecast				o l					
	- Historical average – Currently Low cost historical currently forecast 19% $15%$ $11%19.154 15.121 12.097$	historical currently 69% - 66535 69.556 66.535	forecast 67%	P63 SKUs foreca 234.67 and 567. Average model p 76.3 Click to view model historical current 12% 19%	st between 19 / unit erformance 4% <i>tels</i> High cost Y forecast 22% 3 22.178					
	SKU price changes By SKU By class Largest 500 changes 0.326% overall change 0	Biggest changes Positive & Negative drug Name_of_drug_number_1 Name_of_drug_number_2 Name_of_drug_number_3 Name_of_drug_number_4	current price 23.56 / unit 23.56 / unit 23.56 / unit 23.56 / unit	V forecast price 146.90 / unit 146.90 / unit 146.90 / unit 146.90 / unit	View all forecast changes clirection & difference 123.34 / unit 123.34 / unit 123.34 / unit 123.34 / unit 123.34 / unit					
		Name_of_drug_number_5	23.56 / unit	146.90 / unit	123.34 / unit					

Optimizing crop yield





Determining causes of customer churn PGi

ureoa	Analyses / Churn Risk Analysis			•						
	•						8	C		
?? <i>f</i> .,	Churn Risk Analysis									
(×)	Churn risk overview									
٩	Likelihood of potential losses			Model & risk factors			view	model		
<u>100</u>	\$15,000	:	\$125,345		odel accuracy					
© ₽	0.75			High-severity tickets: billing _discrepancy, service_outage, se Product types: Audio, Package Usage is declining PMI economic factor		vice_outage, service_quality	ervice_quality			
0										
	High risk of chum: ≥ 5x likelihood of chuming in the next 3 months									
	4,803						.			
		5 x greater than average churn risk				> 15 x gre	ater than average churn	risk		
	accounts at high chum risk in the next 3 months	High risk (5 - 8.5x average risk) 3,726	view accounts	Medium high risk (8.6 - 11.3x a 931	verage risk) view accounts	Extremely high risk (11.4	- 15x average risk) view accour	its		
	 List of high risk accounts 									
	High risk accounts		Ŧ	< 1 - 20 of 4	803	C	Search			
	account	chum risk	risk change last	3 mos risk factors			rep			
	IBC Contractors	15x more likely to churn	12% incre	ase billing _discrepancy, s	ervice_outage, servic	e_quality, Usage_decline	Deb Pfister			
	Monty Cardozzo Realty	15x more likely to churn	13% incre	ase billing _discrepancy, s	ervice_outage, servic	e_quality, Usage_decline	Chrales Mangrab			
	Herculean Feet Sports Shoes, LLC	15x more likely to churn	📕 0.5% dec	rease billing _discrepancy, s	ervice_outage, servic	e_quality, Usage_decline	Chester Wiggins			



Conclusions

- Machine intelligence extracts meaning from data
- Some companies employing machine intelligence today
- Many new applications ahead of us



Blog: http://blog.nutonian.com
 Twitter: @Nutonian

Michael Schmidt Founder & CTO michael@nutonian.com

www.nutonian.com