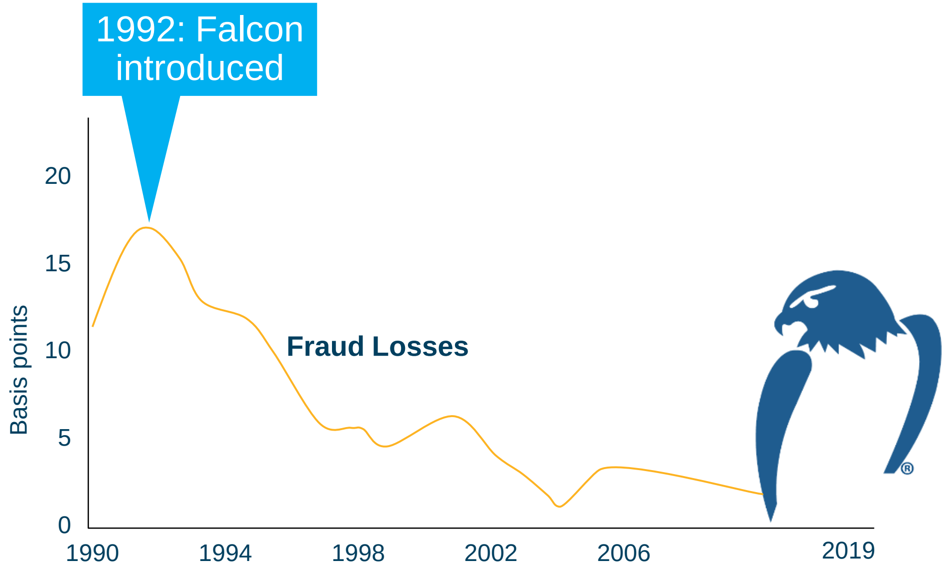
Deep But Explainable: Explainable Latent Feature Neural Networks

Scott Zoldi
Chief Analytics Officer, FICO

Shafi Rahman
Sr. Principal Scientist, FICO

FICO has 30+ years of Machine Learning Experience

1992: First ML based patent issued for FICO® Falcon® Fraud Manager



3000 ML research years

197 issued patents

102 pending patent applications

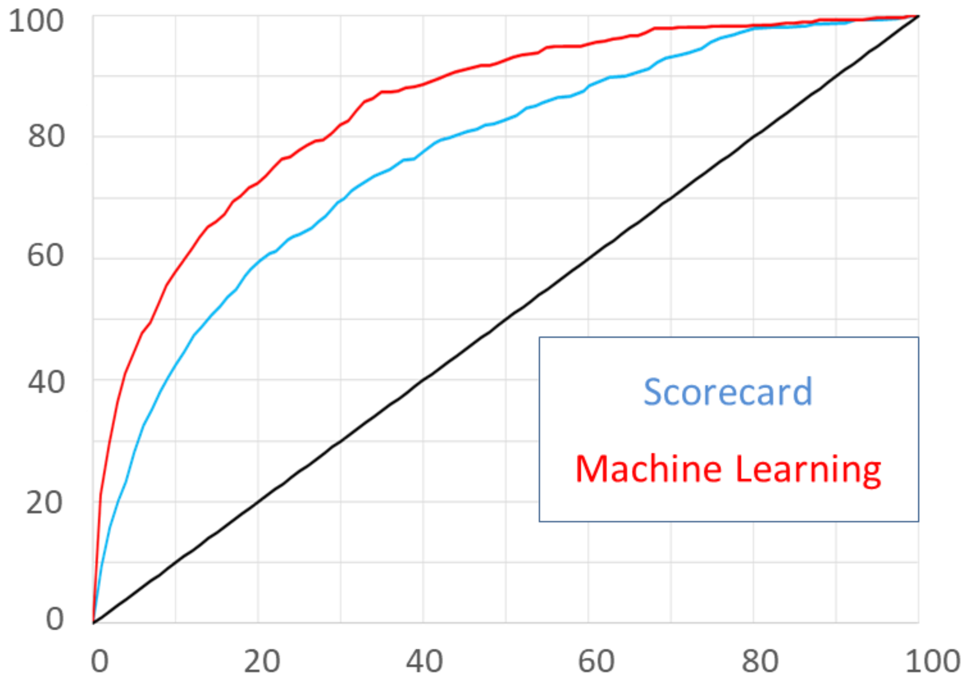
125+ patents in ML to date

Substantial Improvements in Credit Risk Space with Machine Learning Models

Home Equity Portfolio

– Bad rate of 7.7%

~15% improvement in KS over Scorecard



FICO® Score Using Neural Networks

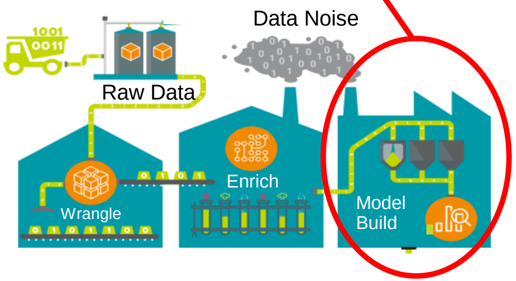
Neural Networks Yield Modest Predictive Lift; Significantly More Streamlined Model Build

< 2%*

Predictive Lift

40 vs 800

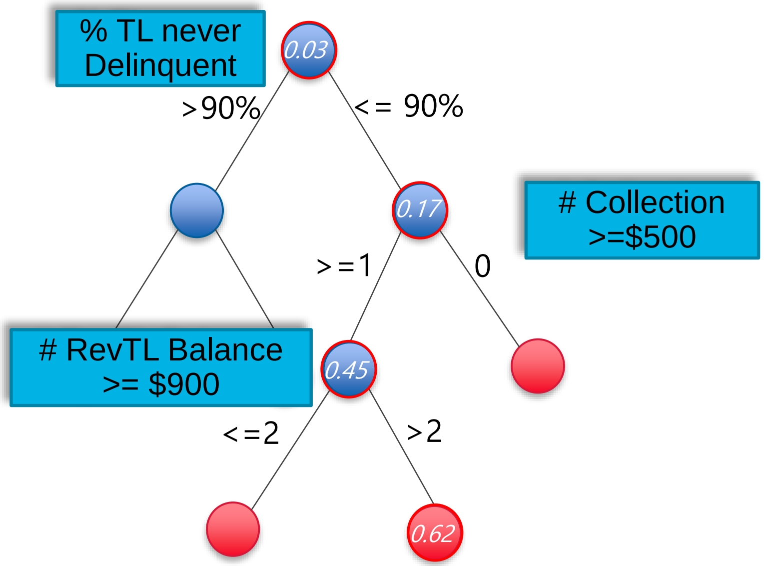
Resource hours required to build model (vs status quo approach)



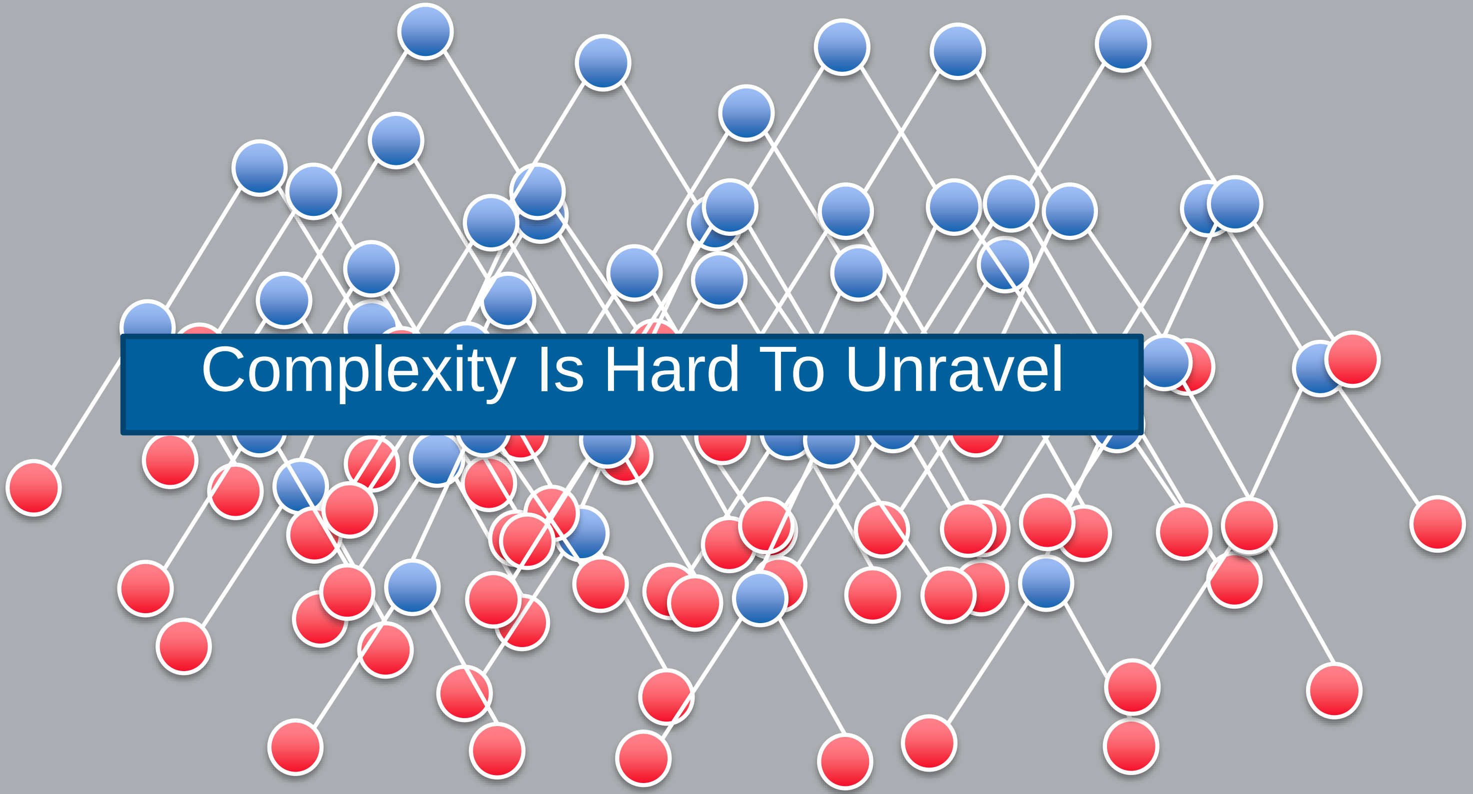
* Measured by relative % improvement in KS statistic on in-time holdout sample

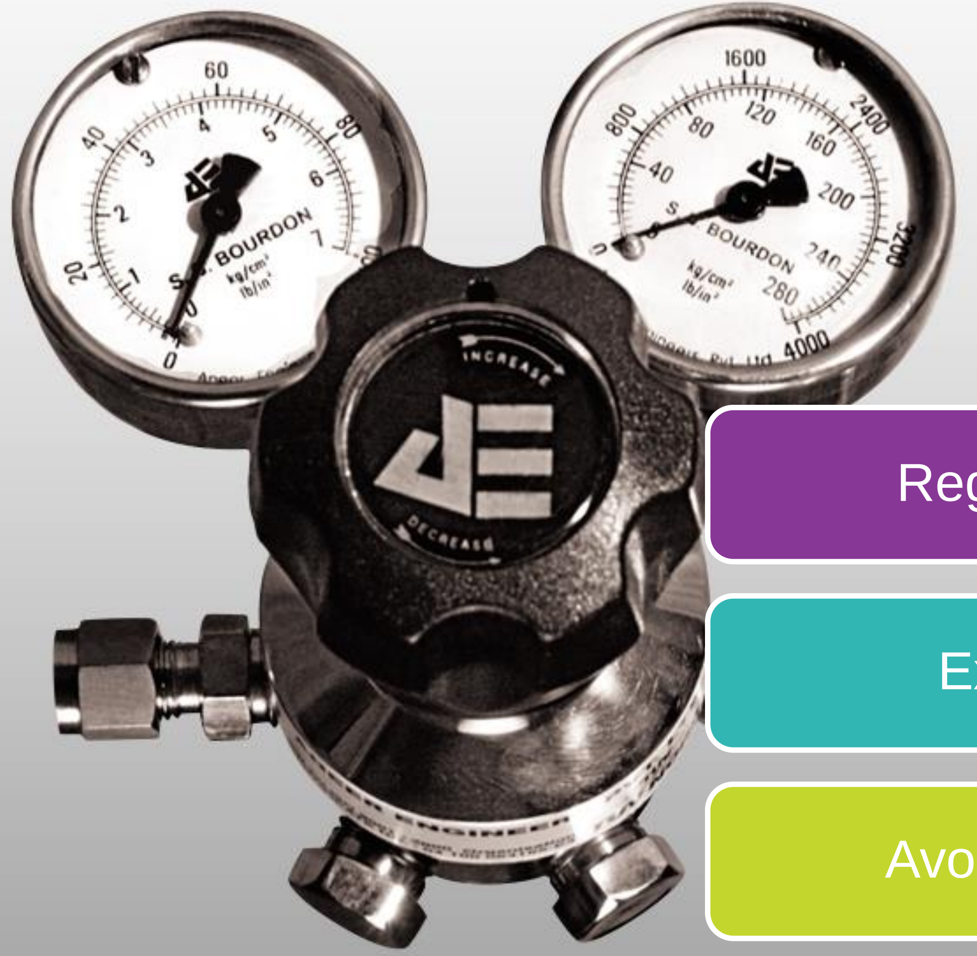
Decision Tree

Probability of Default



Wrong Choice of Machine Learning Can Be Murky





Regulatory Requirements

Executive Acceptance

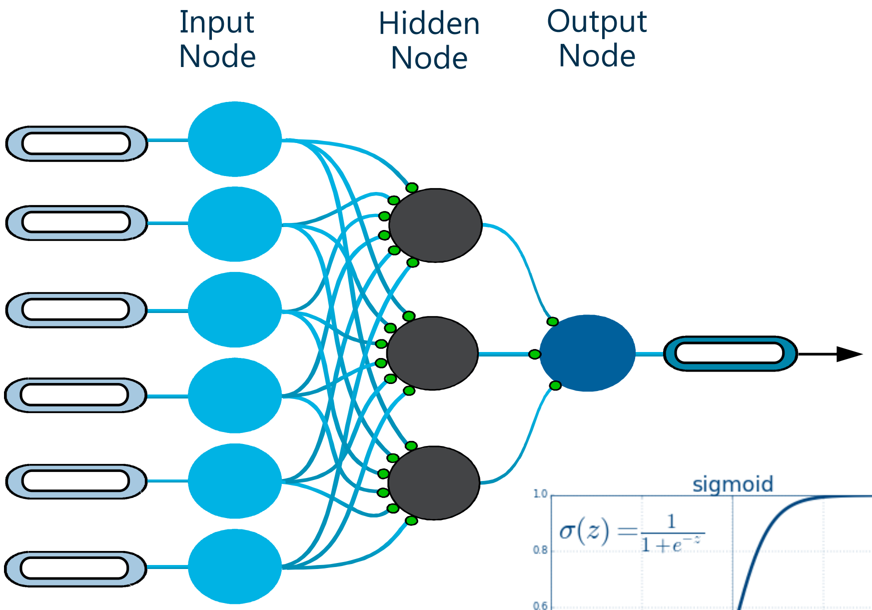
Avoiding Biased Decisions

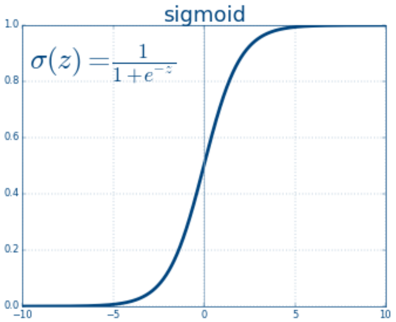
Neural Network Technology

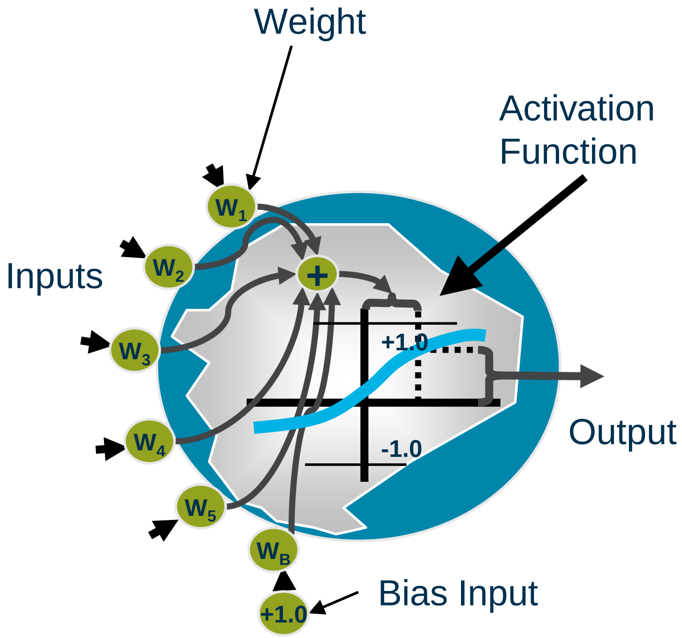
90% Percentage of the US payment cards covered by FICO fraud solutions

2.6B Active financial accounts protected by FICO worldwide

Neural Networks Are The Most Classic Machine Learning Technique

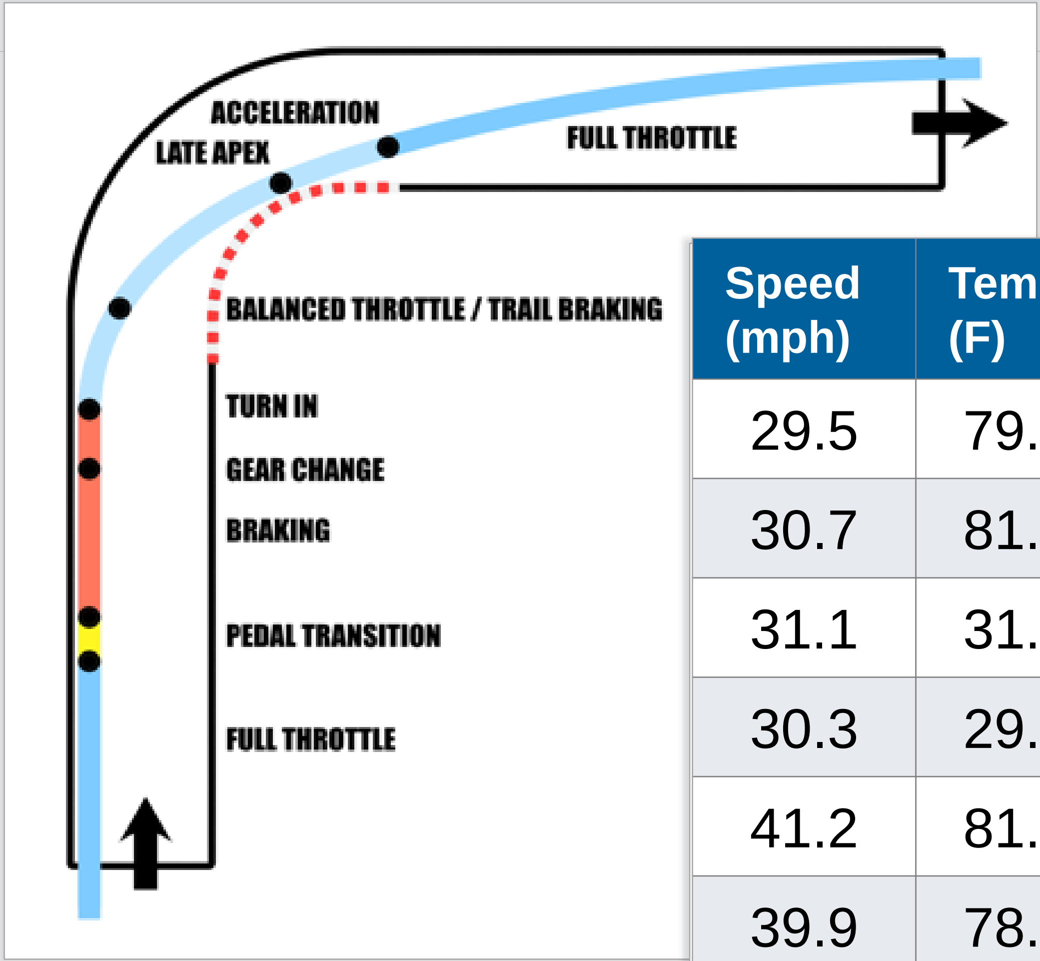




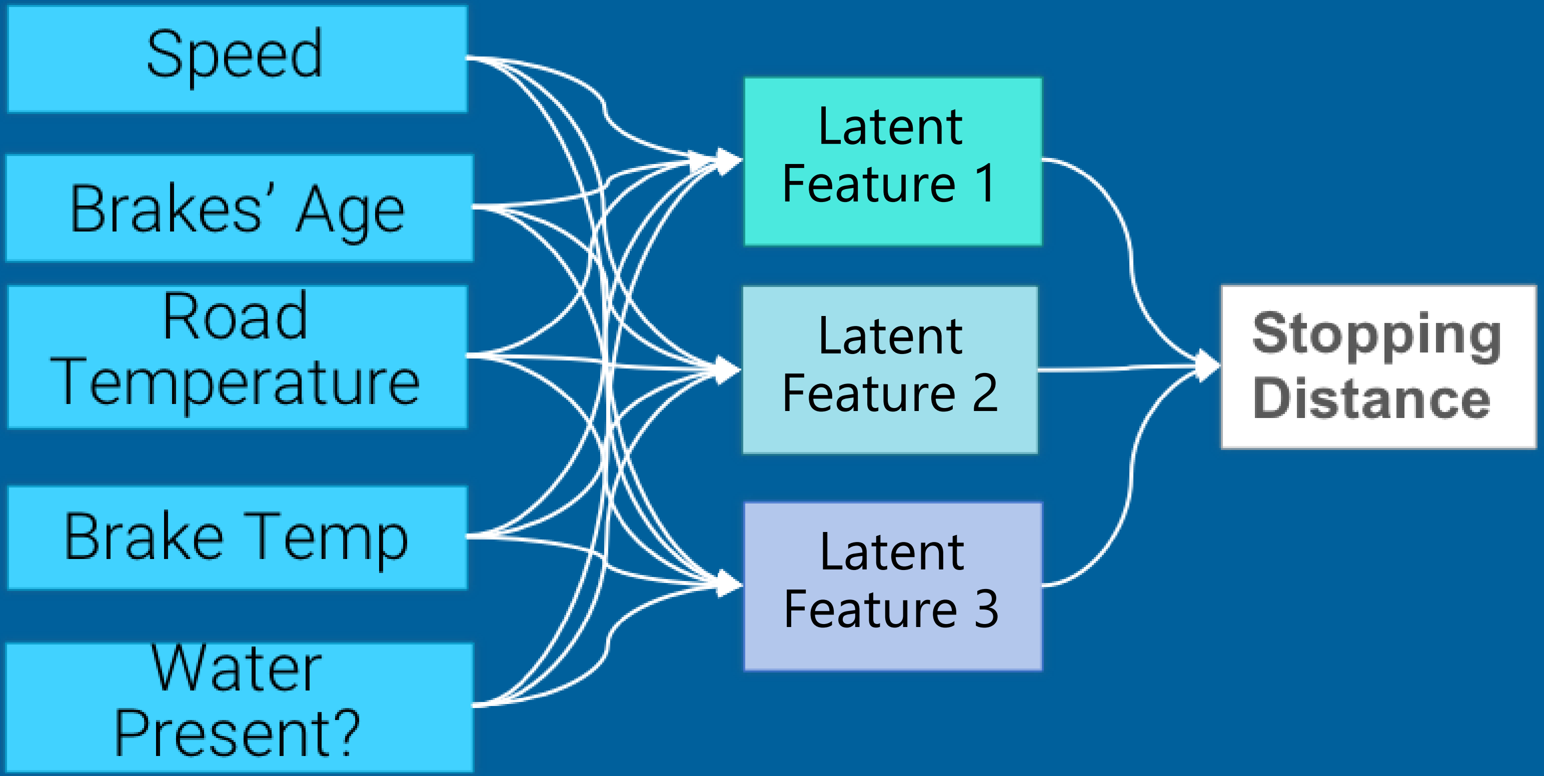


Learns non-linear relationships

How do Neural Networks Work?

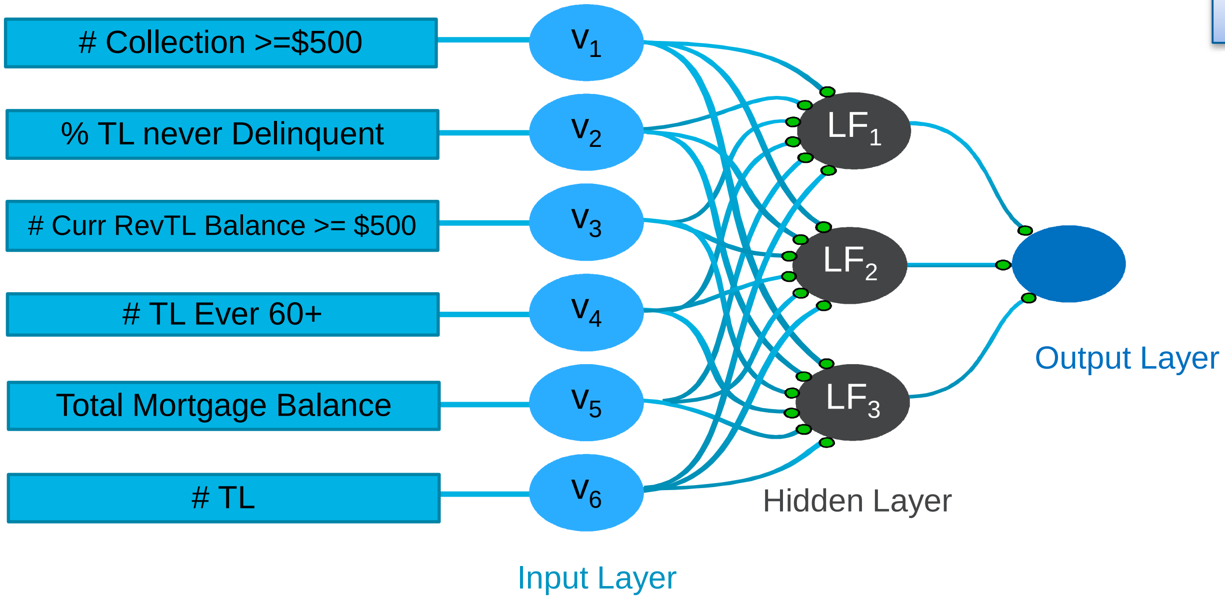


Speed (mph)	Temp (F)	Water ?	…	Stopping dist (ft)
29.5	79.9	No	…	45
30.7	81.0	Yes	…	91
31.1	31.9	No	…	51
30.3	29.8	Yes	…	269
41.2	81.1	No	…	82
39.9	78.7	Yes	…	159



WHAT DID IT LEARN? Do we know?

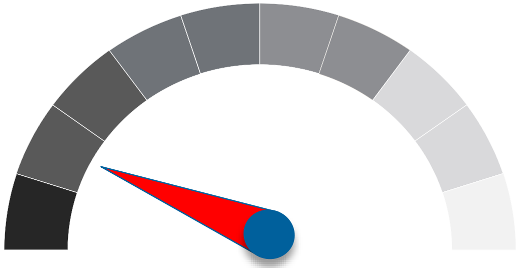
Applying Machine Learning To Mortgage Origination Problem



Cost Function

$$C(w) = \frac{1}{2p} \sum_x \|y(x) - a(x)\|^2$$

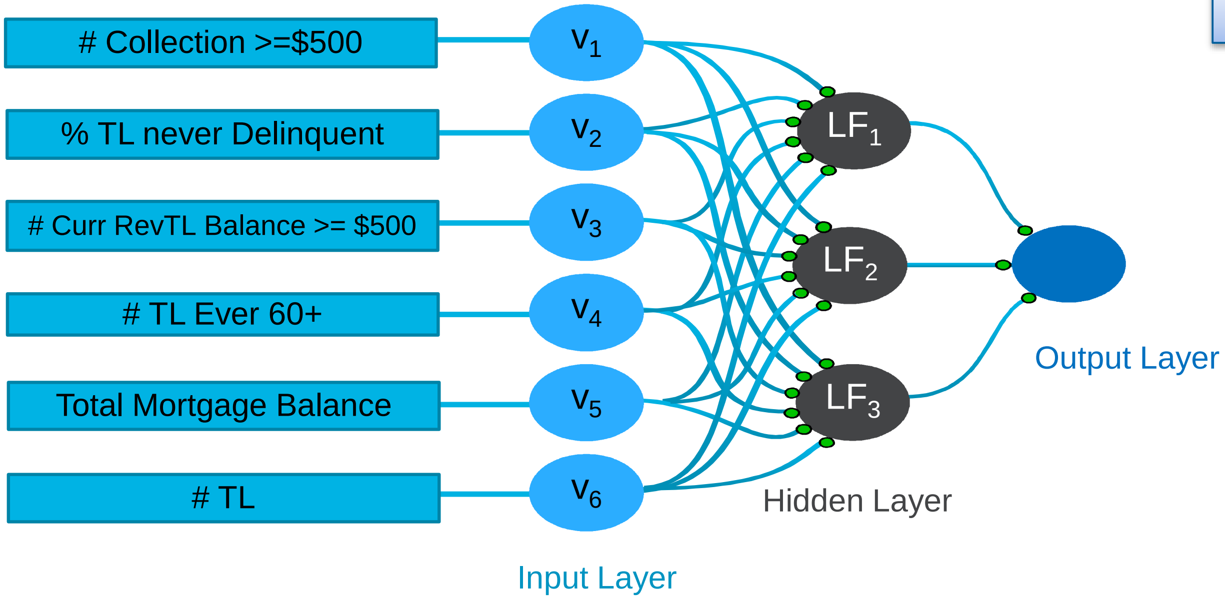
~15% improvement in KS over Scorecard



Interpretability Meter

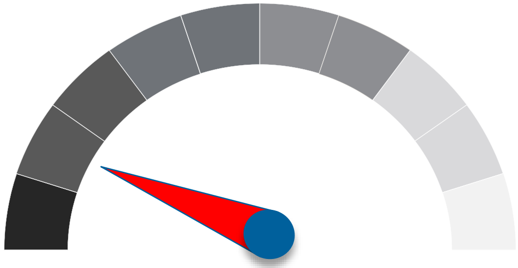
Patent 15/985,130 (USA)

Change The Cost Function



Cost Function

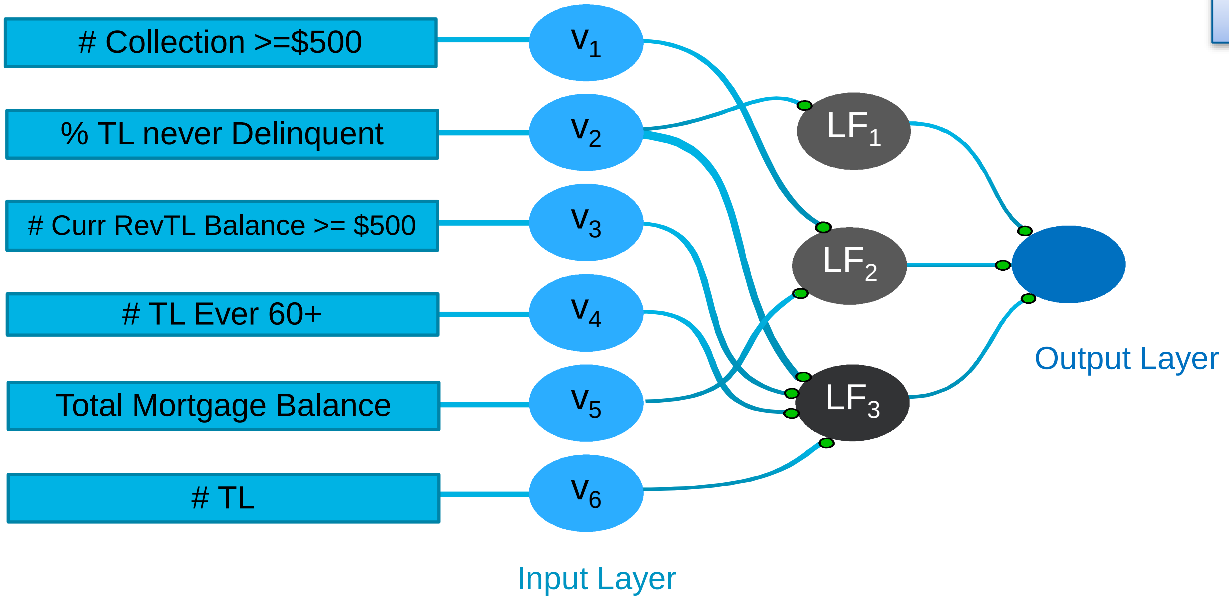
$$C'(w) = C(w) + \frac{\lambda}{p}\sum |w|$$



Interpretability Meter

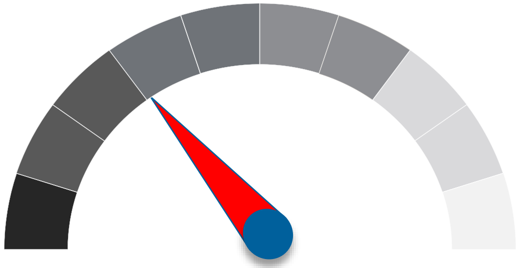
Patent 15/985,130 (USA)

Determine Edges That Don't Contribute



Cost Function

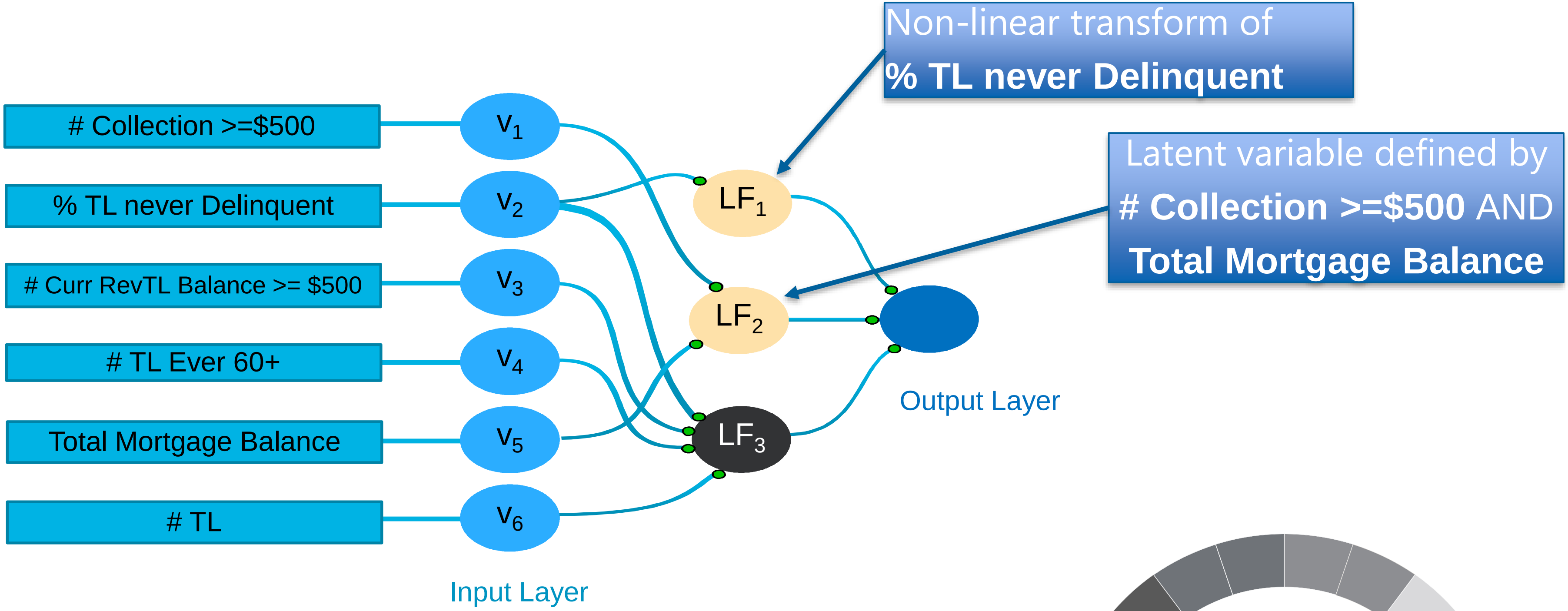
$$C'(w) = C(w) + \frac{\lambda}{p}\sum |w|$$

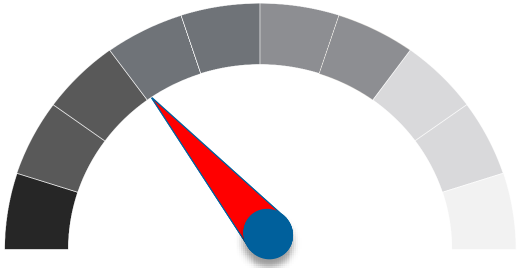


Interpretability Meter

Patent 15/985,130 (USA)

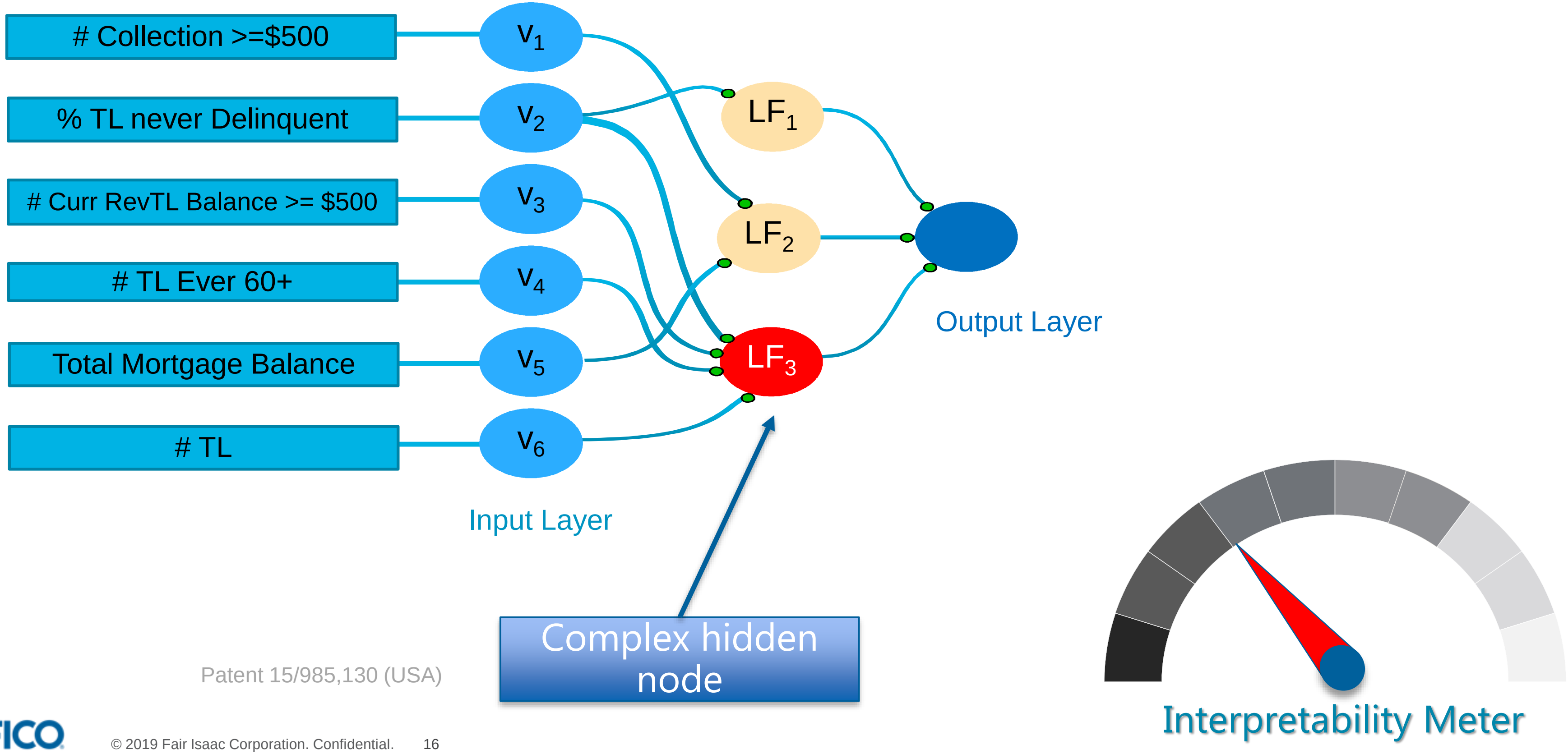
Some Hidden Nodes Are Interpretable Functions of Input Variables





Patent 15/985,130 (USA)

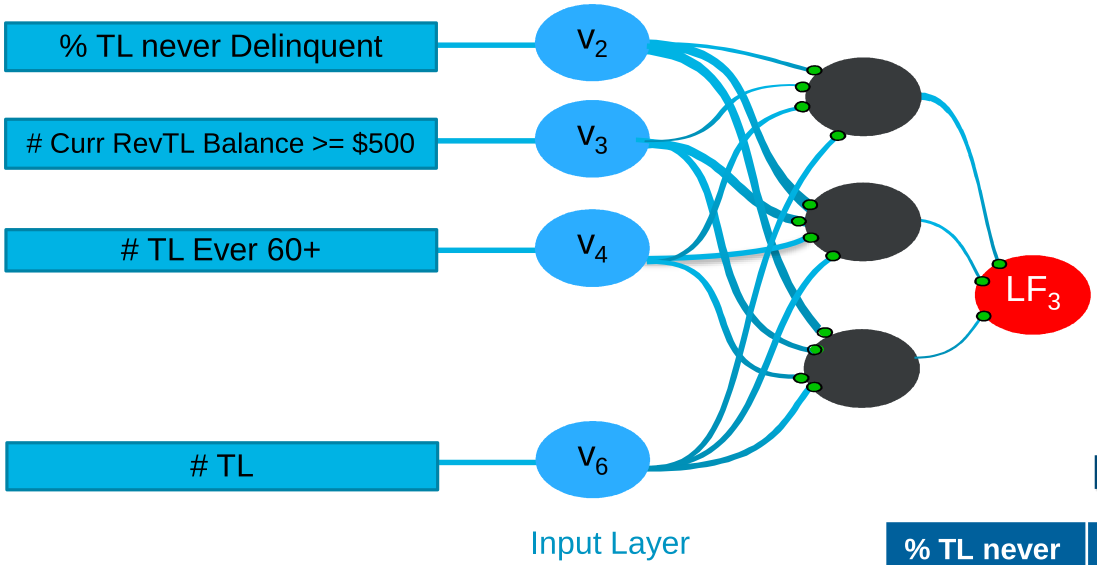
Identify All Complex Hidden Nodes



Patent 15/985,130 (USA)

Explode the Complex Nodes

Train a Fully Connected Neural Network with complex hidden node's activation as the target

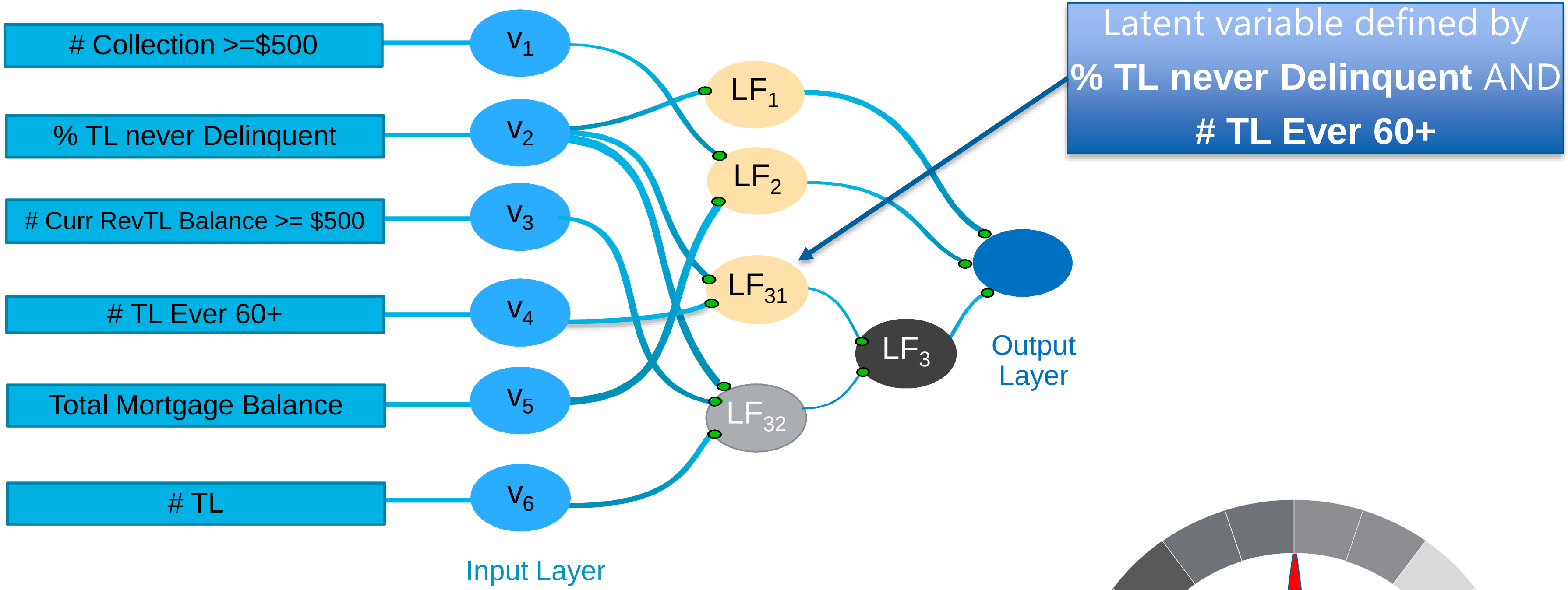


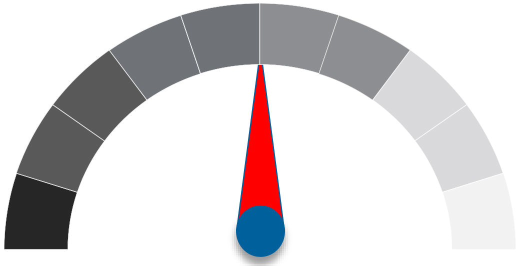
New Training Dataset

% TL never Delinquent	# Curr RevTL Balance >= $500	# TL 60+ Overdue Ever	# TL	LF_3
77.8	3	0	9	0.41
100	1	0	5	-0.3
83.3	2	1	6	0.89

Patent 15/985,130 (USA)

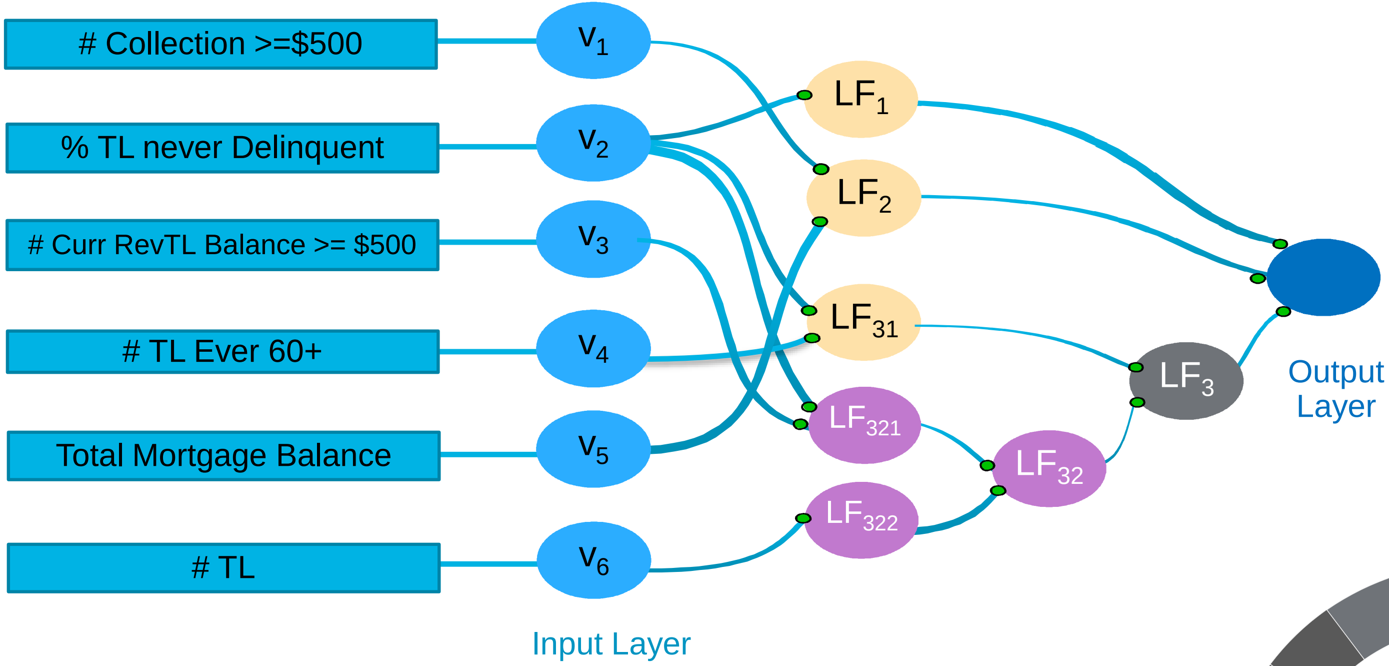
Superimpose Rest of the Interpretable Model





Patent 15/985,130 (USA)

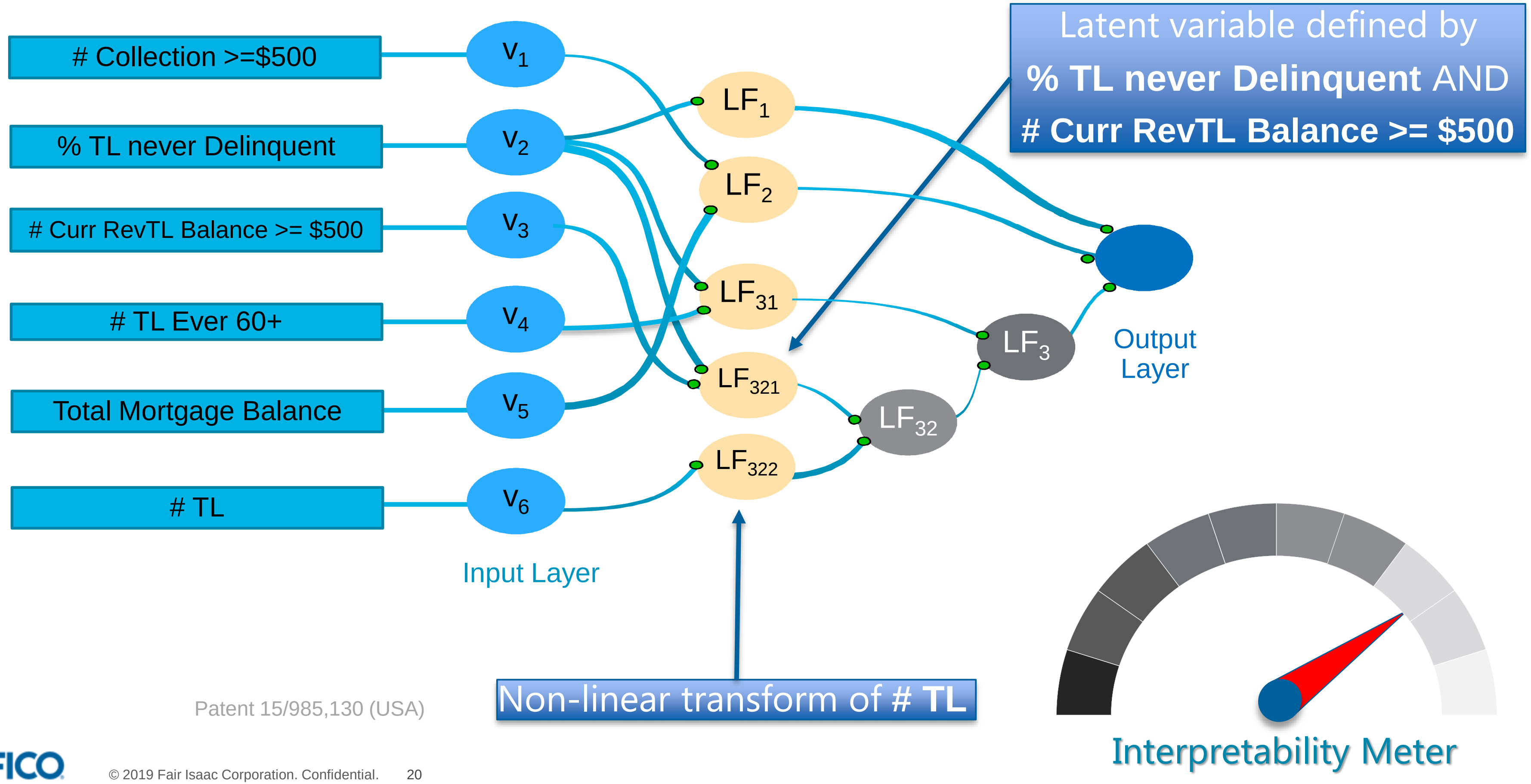
Final Model Has No Complex Nodes



Patent 15/985,130 (USA)

FICO

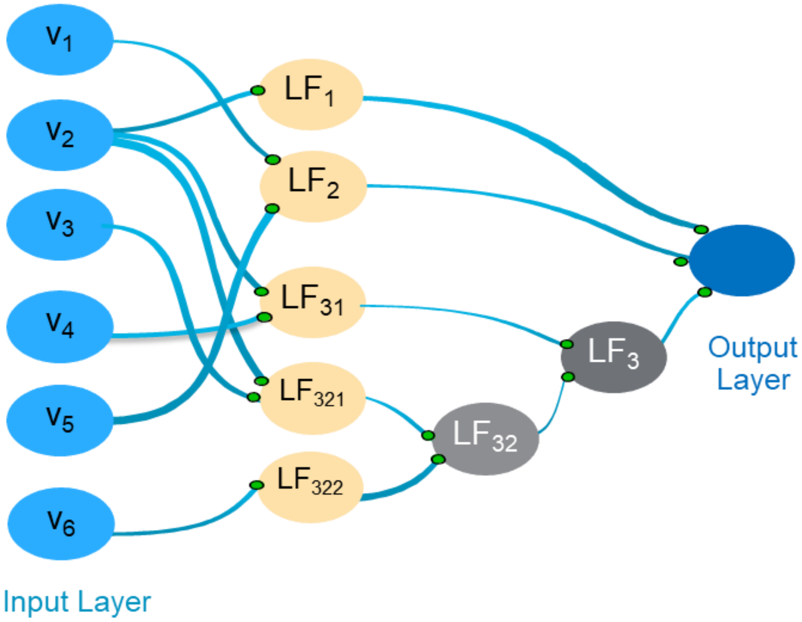
Final Model Has No Complex Nodes



Patent 15/985,130 (USA)

Use Case #1: Using Interpretable Latent Features Models Directly

Brave New World of Explainable Neural Network Models

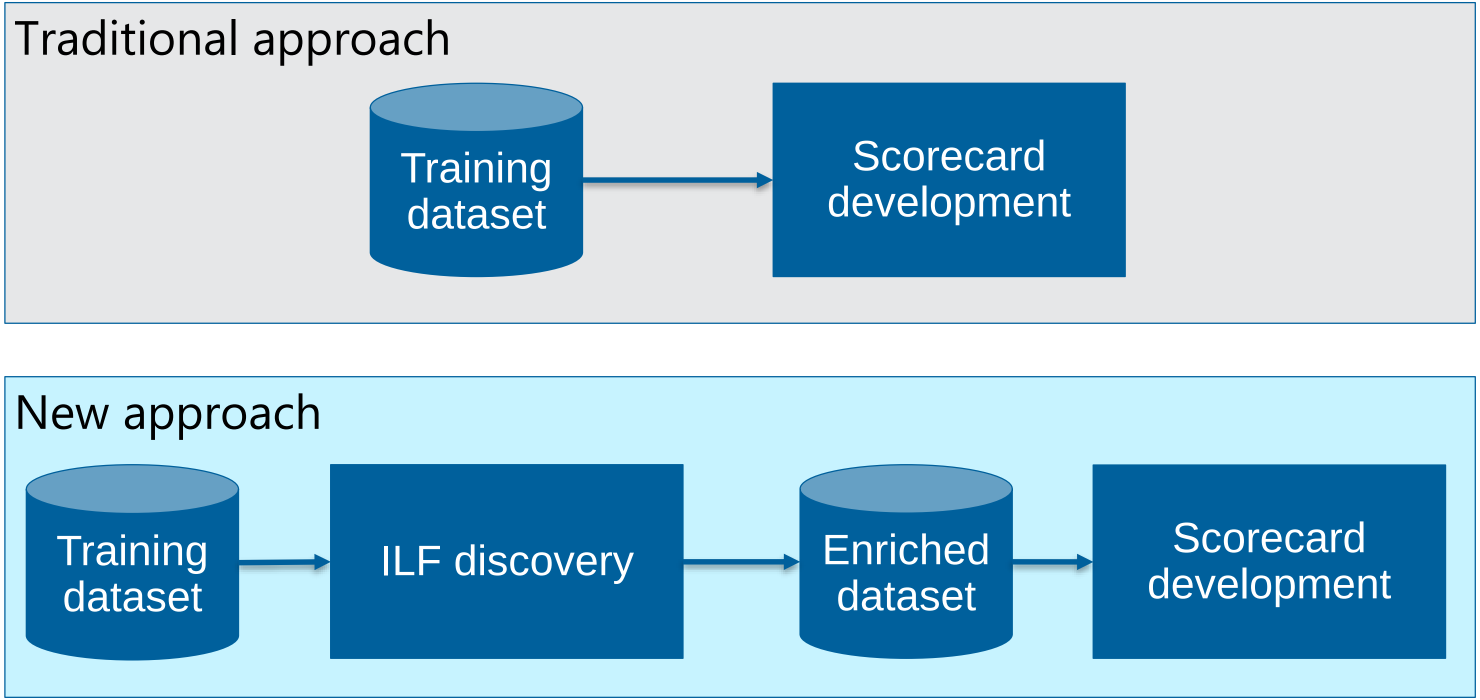


Patent 15/985,130 (USA)

Use The Explainable Neural Network Directly for Origination Decisions

Brave New World of Credit Risk

Use Case #2: Scorecards Enhanced by Interpretable Latent Variables



Scorecards Enhanced by Interpretable Latent Variables

Supplement

with

Explainable Latent Variables

Collection >=$500
AND
Total Mortgage Balance

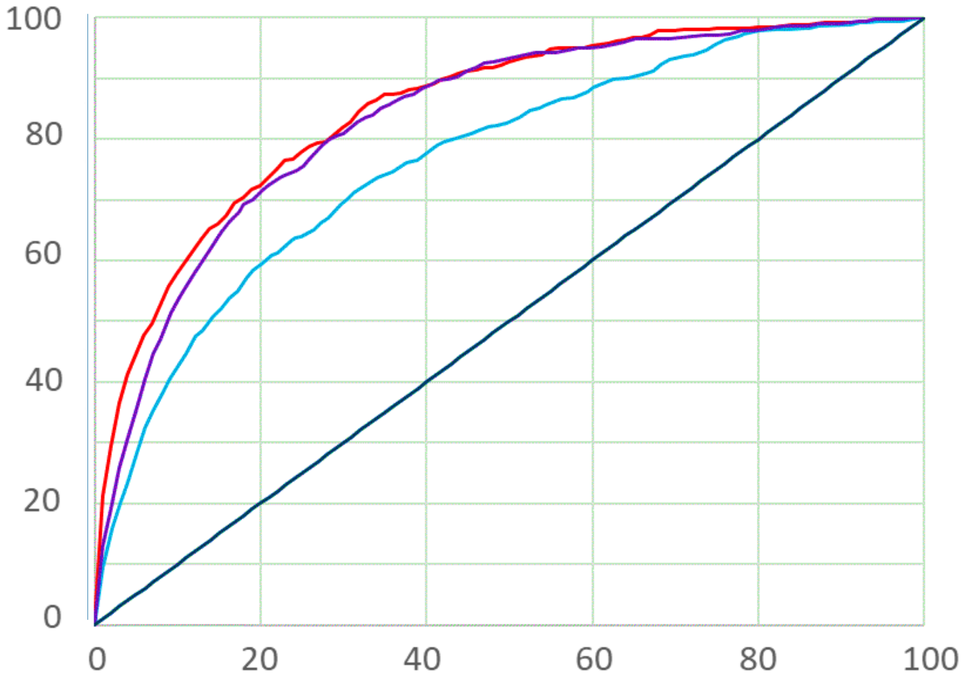
% TL never Delinquent
AND
TL Ever 60+

% TL never Delinquent
AND
Curr RevTL Balance >= $500

Variable	Bin	Score Weight	
	Missing, unknown	53	
	0	53	
	1 – 4	64	64
	5 – 9	75	
	≥ 10	81	
	Baseline score: 81		
	Missing, unknown	78	
	No missed payments	85	85
	0 – 1	50	
	2 – 5	63	
	6 – 11	71	
payment	12 – 23	76	
	≥ 24	79	
	Baseline score: 85		
	Checking & savings	56	
	One account only	52	52
	None	41	
references	Missing, unknown	43	
	Baseline score: 56		

Patent 15/985,130 (USA)

Impact of Using Interpretable Latent Features On Model Performance



ILF XNN Model

ILF enhanced Scorecards

Scorecards

Bringing It All Together

Machine Learning Is Here To Stay

Machine Learning Provides Incredible Performance

Need To Explain The Machine Learning Decisions

Interpretable Latent Features Provide Powerful Way to Bring Machine Learning into Credit Risk

Thank You!

Shafi Rahman
Sr. Principal Scientist, FICO