



# Startup.ML

QuantCon 2016

## Machine Learning Based Cryptocurrency Trading



Machine Learning Fellowship

Startup.ML

# Outline

Exchange tradable cryptocurrency instruments




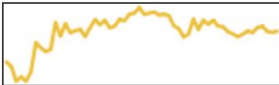






Exchange mechanics and fees

Architecture of an ML-based systematic strategy

Machine learning choices

Fellowship process to develop systematic strategies

# Cryptocurrency Flavors and MCaps

#	Name	Market Cap	Price	Available Supply	Volume (24h)	% Change (24h)	Price Graph (7d)
1	 Bitcoin	\$ 6,477,017,277	\$ 420.91	15,388,275 BTC	\$ 32,935,500	-0.00 %	
2	 Ethereum	\$ 914,022,103	\$ 11.61	78,716,970 ETH	\$ 6,271,040	1.07 %	
3	 Ripple	\$ 259,153,481	\$ 0.007525	34,439,870,367 XRP *	\$ 334,116	0.95 %	
4	 Litecoin	\$ 147,164,496	\$ 3.26	45,195,026 LTC	\$ 778,374	-0.11 %	
5	 Dash	\$ 42,470,529	\$ 6.70	6,340,721 DASH	\$ 229,393	-6.62 %	

# Available in ~30 Quote Currencies

Overview		Currencies																All Markets
All	KRW	NMC	IDR	RON	ARS	AUD	BGN	BRL	BTC	CAD	CHF	CLP	CNY	CZK	DKK	EUR	GAU	
GBP	HKD	HUF	ILS	INR	JPY	LTC	MXN	NOK	NZD	PEN	PLN	RUB	SAR	SEK	SGD	SLL	THB	
UAH	USD	XRP	ZAR															
Symbol		Latest Price	30 days	Average	Volume	Low/High	Bid	Ask	24h Avg.	Volume	Low/High							
▼	<b>Bitfinex</b>	<b>419.2</b>		<b>412.56</b>	<b>371,878.86</b>	<b>389</b>	<b>419.2</b>	<b>419.25</b>	<b>419.75</b>	<b>2,194.16</b>	<b>418.6</b>							
USD	bitfinexUSD	2 min ago	6.64 1.61%	153,423,053.70 USD	431	-0.55 -0.13%	920,996.78 USD	<b>420.79</b>										
▼	<b>Coinbase</b>	<b>419.48</b>		<b>412.62</b>	<b>195,723.11</b>	<b>381.09</b>	<b>419.49</b>	<b>419.55</b>	<b>419.64</b>	<b>3,296.23</b>	<b>418.51</b>							
USD	coinbaseUSD	0 min ago	6.86 1.66%	80,759,360.46 USD	426.5	-0.16 -0.04%	1,383,240.21 USD	<b>420.38</b>										
▼	<b>BitStamp</b>	<b>417.87</b>		<b>412.27</b>	<b>142,419.21</b>	<b>382</b>	<b>417.87</b>	<b>417.9</b>	<b>418.18</b>	<b>1,602.70</b>	<b>416.1</b>							
USD	bitstampUSD	3 min ago	5.60 1.36%	58,714,707.38 USD	427.99	-0.31 -0.07%	670,211.40 USD	<b>419.5</b>										
▲	<b>btc·e</b>	<b>416.051</b>		<b>413.68</b>	<b>134,150.32</b>	<b>393.996</b>	<b>415.981</b>	<b>416.192</b>	<b>415.66</b>	<b>2,886.36</b>	<b>413.101</b>							
USD	btceUSD	0 min ago	2.37 0.57%	55,495,922.62 USD	427	0.39 0.10%	1,199,733.16 USD	<b>416.8</b>										
▼	<b>itBit</b>	<b>416.41</b>		<b>412.90</b>	<b>81,733.31</b>	<b>386</b>	<b>417.19</b>	<b>417.68</b>	<b>417.88</b>	<b>2,960.94</b>	<b>416</b>							
USD	itbitUSD	26 min ago	3.51 0.85%	33,747,462.50 USD	426.33	-1.47 -0.35%	1,237,327.12 USD	<b>419.73</b>										
▲	<b>LocalBitcoins</b>	<b>474.96</b>		<b>478.09</b>	<b>61,061.86</b>	<b>271.53</b>	<b>41504160417</b>	<b>410.35</b>	<b>471.08</b>	<b>1,321.07</b>	<b>353.86</b>							
USD	localbtcUSD	3 min ago	-3.13 -0.66%	29,193,190.48 USD	4373.18	3.88 0.82%	622,324.28 USD	<b>2099.08</b>										
▼	<b>Kraken</b>	<b>420.079</b>		<b>412.87</b>	<b>49,662.06</b>	<b>387.27</b>	<b>419.33</b>	<b>420.079</b>	<b>420.49</b>	<b>525.75</b>	<b>418.61</b>							
USD	krakenUSD	1 min ago	7.21 1.75%	20,503,742.92 USD	429.999	-0.41 -0.10%	221,073.11 USD	<b>422</b>										
▼	<b>The Rock Trading Company</b>	<b>419.34</b>		<b>415.32</b>	<b>1,536.24</b>	<b>390</b>	<b>419.01</b>	<b>419.64</b>	<b>420.65</b>	<b>9.80</b>	<b>419.34</b>							
USD	rockUSD	3 hrs, 45 min ago	4.02 0.97%	638,026.48 USD	429.77	-1.31 -0.31%	4,122.76 USD	<b>421.69</b>										

# How a Bitcoin transaction works

Bob, an online merchant, decides to begin accepting bitcoins as payment. Alice, a buyer, has bitcoins and wants to purchase merchandise from Bob.

## WALLETS AND ADDRESSES



Bob and Alice both have Bitcoin "wallets" on their computers.



Wallets are files that provide access to multiple Bitcoin addresses.



An address is a string of letters and numbers, such as 1HULMwZEPkJPeCh438eKJLybLCWhDpN.



Bob creates a new Bitcoin address for Alice to send her payment to.

## CREATING A NEW ADDRESS

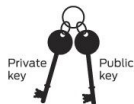


Each address has its own balance of bitcoins.

## SUBMITTING A PAYMENT



Alice tells her Bitcoin client that she'd like to transfer the purchase amount to Bob's address.



### Public Key Cryptography 101

When Bob creates a new address, what he's really doing is generating a "cryptographic key pair," composed of a private key and a public key. If you sign a message with a private key (which only you know), it can be verified by using the matching public key (which is known to anyone). Bob's new Bitcoin address represents a unique public key, and the corresponding private key is stored in his wallet. The public key allows anyone to verify that a message signed with the private key is valid.

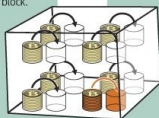
It's tempting to think of addresses as bank accounts, but they work a bit differently. Bitcoin users can create as many addresses as they wish and in fact are encouraged to create a new one for every new transaction to increase privacy. So long as no one knows which addresses are Alice's, her anonymity is protected.



Gary, Garth, and Glenn are Bitcoin miners.

## VERIFYING THE TRANSACTION

The miners' computers bundle the transactions of the past 10 minutes into a new "transaction block."



The miners' computers are set up to calculate cryptographic hash functions.

Private key

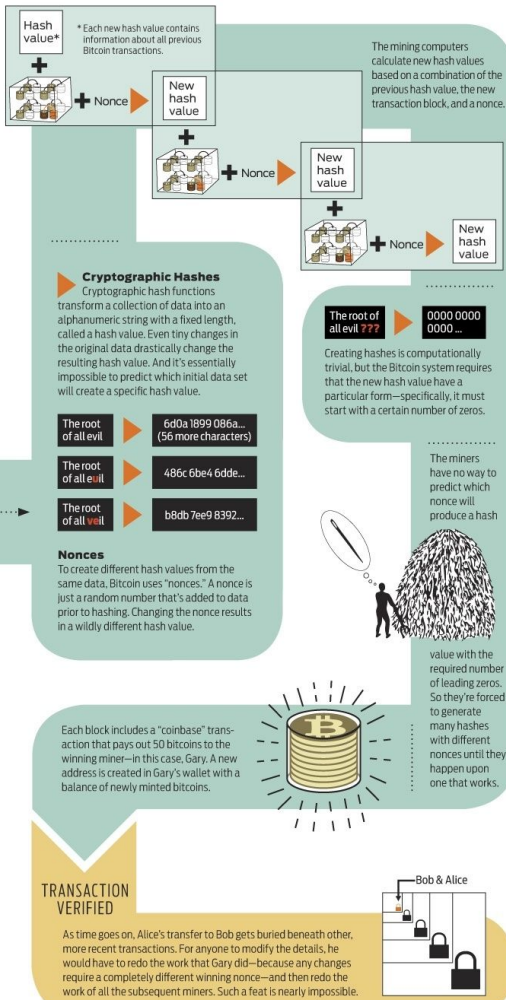


Alice's wallet holds the private key for each of her addresses. The Bitcoin client signs her transaction request with the private key of the address she's transferring bitcoins from.



Public key

Anyone on the network can now use the public key to verify that the transaction request is actually coming from the legitimate account owner.



# Modern Exchanges Being Built

Real-time order book (level 3)

Websocket Feed

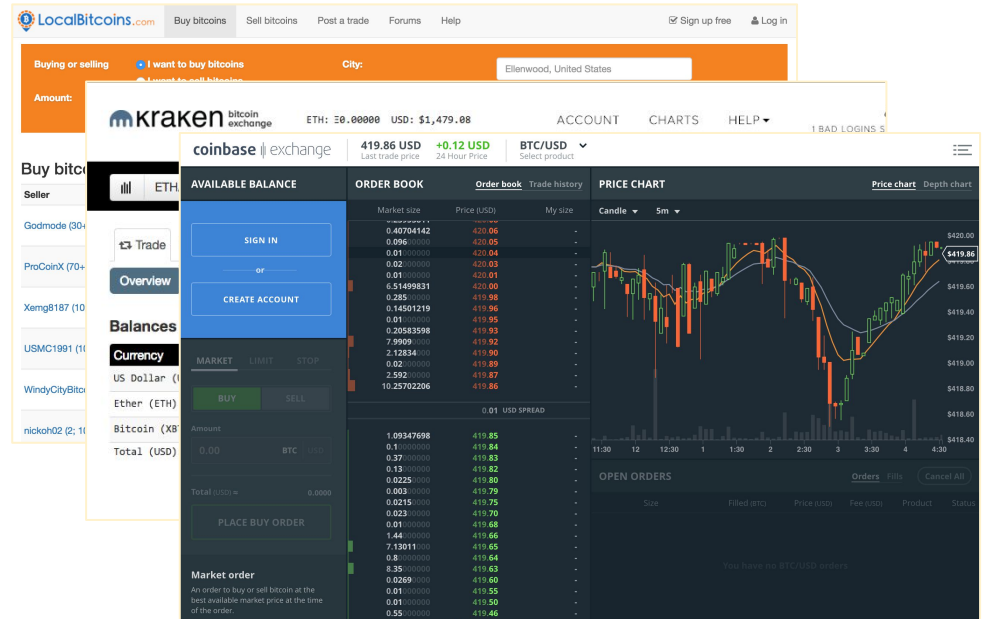
Colocation (aws region)

REST end-points orders, account, fills

FIX 4.2 support

Reasonable rate limit (3 req. / sec)

Python / Ruby sample code





# Fee Structures Encourage Market Making



USER 30 DAY VOLUME	TAKER FEE
> 0 % (~ 0.00 BTC)	0.25 %
> 1 % (~ 1,925.87 BTC)	0.24 %
> 2.5 % (~ 4,814.68 BTC)	0.22 %
> 5 % (~ 9,629.36 BTC)	0.19 %
> 10 % (~ 19,258.73 BTC)	0.15 %
> 20 % (~ 38,517.45 BTC)	0.10 %

*Note: Taker trades are charged 0.25% fee at the time of trade but a rebate for the previous 24 hours of trading fees will be*

## Fee Schedule

Maker	Taker	Volume
0.16%	0.26%	< 50,000
0.14%	0.24%	< 100,000
0.12%	0.22%	< 250,000
0.10%	0.20%	< 500,000
0.08%	0.18%	< 1,000,000
0.06%	0.16%	< 2,500,000
0.04%	0.14%	< 5,000,000
0.02%	0.12%	< 10,000,000
0.00%	0.10%	> 10,000,000

# Market Making Introduces Execution Risks

Limit orders are harder to time

When the prediction is right, execution is particularly challenging

Introduces more parameters that need to be optimized

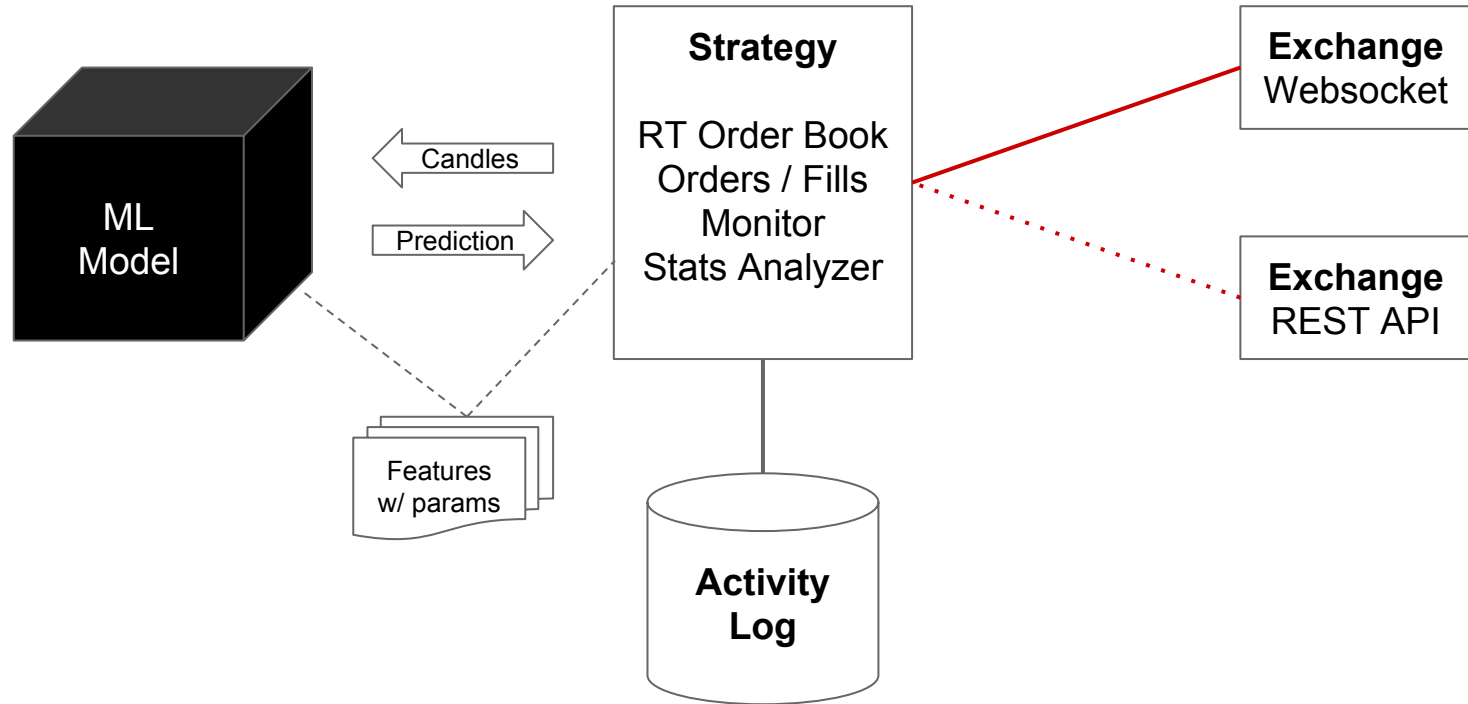
Taker strategies are easier but may require leverage

Bitfinex (3.3x), Kraken (5x)

Beware of clawbacks and exchange risks



# Deployment Architecture



# ML-Based Strategy Considerations

## Input Features

Price differences

Lagged windows

Technical indicators

Order book pressure

## Prediction Types

Point regression

Slope regression

Binary classification

Multi-class classification

## Parameters

Algorithm params

Candle size

Buy / Sell threshold(s)

Stop loss

Order wait (attempts/time)

Order commit threshold

Max hold

Bet size

Allocation

# Picking the Best Modeling Approach

## Representation

instances  
  k-nearest neighbor  
  support vector machine  
hyperplanes  
  naïve bayes  
  logistic regression  
decision trees  
set of rules  
  propositional rules  
  logic programs  
neural networks  
graphical models  
  bayesian networks  
  conditional random fields

## Evaluation

accuracy / error rate  
precision and recall  
squared error  
likelihood  
posterior probability  
information gain  
k-l divergence  
cost/utility  
margin

## Optimization

combinatorial optimization  
  greedy search  
  beam search  
  branch-and-bound  
continuous optimization  
  unconstrained  
    gradient descent  
    conjugate gradient  
    quasi-newton method  
  constrained  
    linear programming  
    quadratic programming

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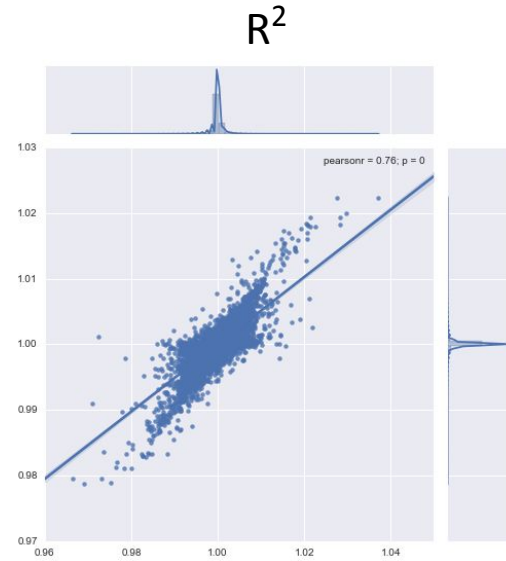
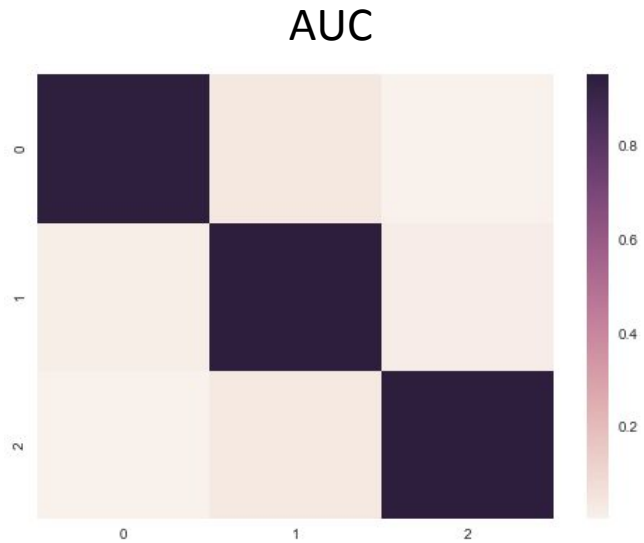
Order commit threshold

Max hold

Bet size

Allocation

# Evaluating Model Fit



# ML-Based Strategy Considerations

## Input Features

Price differences

Lagged windows

Technical indicators

Order book pressure

## Prediction Types

Point regression

Slope regression

Binary classification

Multi-class classification

## Parameters

Algorithm params

Candle size

Long/short threshold(s)

Stop loss

Order wait (attempts/time)

Order commit threshold

Max hold

Bet size

Allocation

# Strategy Optimization

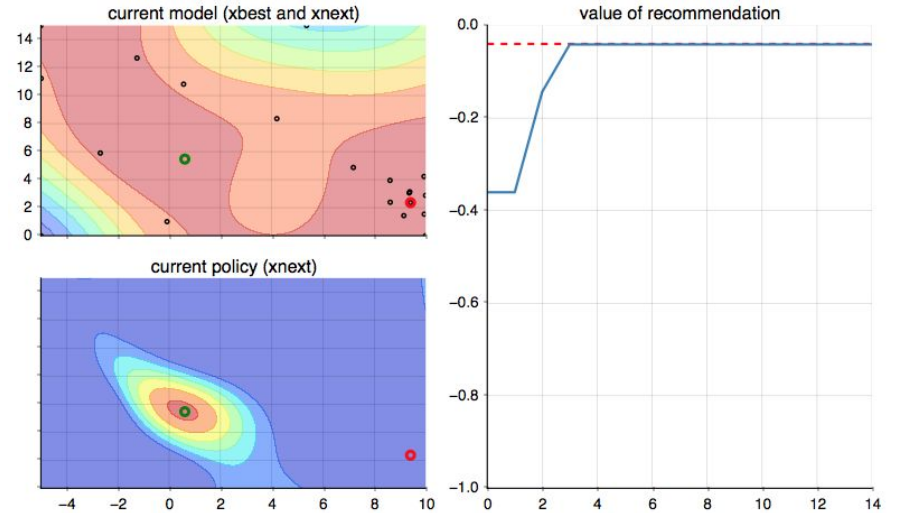
Dozens of parameters

Many difficult to simulate

Hours / days to optimize

Significantly more dynamic than prediction

Next set of machine learning challenges!





# Temporal Strategies, Continuous Process

Real-world machine learning applications

Immersive 4 month program

Program almost exclusively hands-on practice

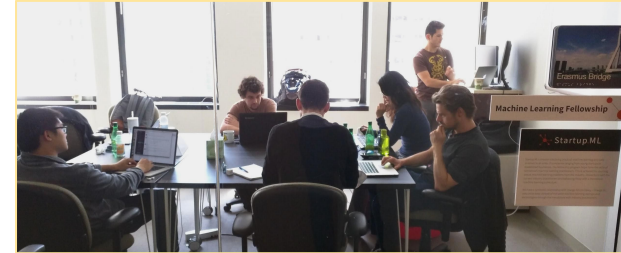
Agile software development methodology

Mentoring by experienced data scientists

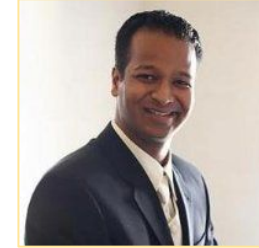
1 mentor : 4 fellows ratio

Acceptance rate < 3%

Free to the fellows



# Experienced Mentor Team



# Fellows Doing Meaningful Data Science Work



Alex Chao, Uber ATC



Rewon Child, Enlitic



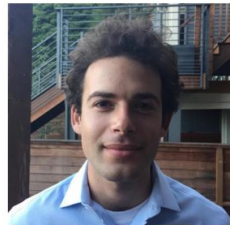
Angie Hsieh



George Manuelpillai, Orange



Philip Margolis



Alex Miller, Yelp



Yevhen Mohylevskyy



Saad Eddin Al Orjany



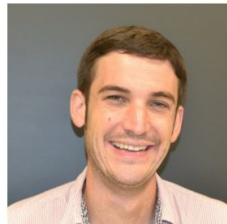
Shonket Ray



Daniel Saltiel, Engineers Gate



Marjorie Sayer, CloudGenix



Peter Skipper, Sentient Technologies



Layla Tadjpour



Vrushank Vora



Eric Wayman, Pivotal







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May 12 @ Bloomberg West Coast Tech Hub