


# Computational Intelligence Meets Financial Forecasting

Edward Tsang et al  
Forecasting Research Team




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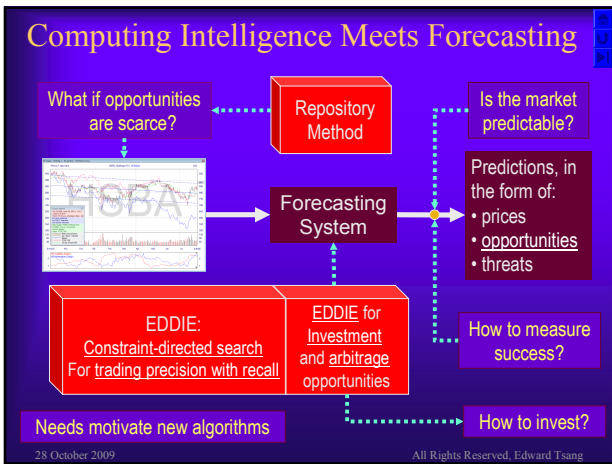
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## Forecasting

Will the price go up or down?  
By how much?

What data do we have?  
Daily? Intraday (*high frequency*)? Volume?  
Indices? Economic Models?

What is the risk of crashing?

Are Option and Future prices aligned?  
(i.e. are there arbitrary opportunities?)

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## Efficient Market Hypothesis

- ◆ Financial assets (e.g. shares) pricing:
  - All available information is fully reflected in current prices
- ◆ If EMH holds, forecasting is futile
  - Random walk hypothesis
- ◆ Assumptions:
  - Efficient markets (one can buy/sell quickly)
  - Perfect information flow
  - Rational traders

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## Is the market really efficient?

- ◆ Market may be efficient in the long term
- ◆ “*Fat Tail*” observation:
  - big changes today often followed by big changes tomorrow (either up or down)
- ◆ How fast can one respond to new information?
  - Faster machines certainly help
  - So should faster algorithms (CIDER)
- ◆ Credit crunch: did investors price their risks properly?

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## Do fundamental values matter?

- ◆ In boom, markets are liquid but often not driven by fundamentals only (bubbles)
- ◆ In bust, markets may be driven by fundamentals only, but are not liquid
- ◆ In neither boom nor bust are markets efficient
  - Willem Buiter (LSE)

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## Our Research agenda

- ◆ What would a reasonable agenda be?
- ◆ Predicting the price in 10 days would be good
- ◆ But it may be sufficient if I could turn a 50-50 game into a 60-40 game in my favour
- ◆ Question asked:  
*“Will the price go up (or down) by at least  $r\%$  within the next  $n$  days?”*

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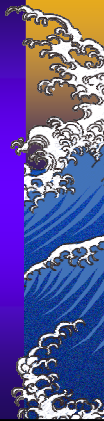
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## How can computational intelligence help?



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## A taste of user input

Given	Expert adds:	More input:		Define target
Daily closing	50 days m.a.	Volatility	.....	↑4% in 21 days?
90	80	50		1
99	82	52		0
87	83	53		1
82	82	51		1
.....	.....	.....		.....

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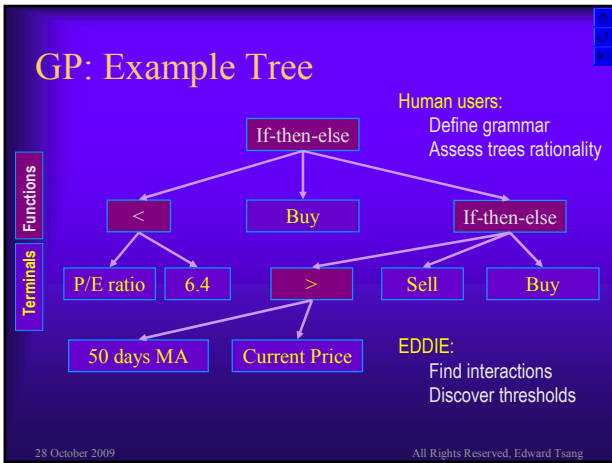
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### Syntax of GDTs in EDDIE-2

```

<Tree> ::= "If-then-else" <Condition> <Tree> <Tree> | Decision
<Condition> ::= <Condition> "And" <Condition> |
               <Condition> "Or" <Condition> |
               "Not" <Condition> |
               Variable <RelationOperation> Threshold
<RelationOperation> ::= ">" | "<" | "="
Terminals:
Variable is an indicator / feature
Decision is an integer, "Positive" or "Negative" implemented
Threshold is a real number

```

◆ Richer language ⇒ larger search space

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### Machine learning basics

What could one learn?  
Hypothetical observations  
How to summarize success/failure?  
Performance measures

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## Hypothetical Situation

- ◆ Suppose you've discovered a good indicator  $R$ 
  - How can you make use of it?
- ◆ Suppose it is a fact that whenever
  - $R$  has a value less than 1.4 or greater than 2.7,
  - the volatility of the share prices is above 2.5, and
  - yield is above 5.7%
 prices will rise by  $\geq 6\%$  within the next 21 days
- ◆ How can you find this rule

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## Hypothetical observations

Instance	$R$	Volatility	Yield	Target	Classified	
1	1.2	3.1	4.8	False	False	TN
2	1.3	3.0	6.6	True	True	TP
3	2.8	2.9	5.9	True	False	FP
4	2.5	1.7	7.0	False	False	TN
5	2.4	3.5	6.9	False	False	TN
6	2.0	2.9	5.6	False	False	TN
7	3.1	3.3	5.8	True	True	TP
8	3.1	3.0	5.5	False	True	FN
9	2.8	2.4	5.0	False	True	FN
10	2.6	2.5	5.2	False	False	TN

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## Confusion Matrix

		Prediction		
		-	+	
Reality	-	5	2	7
	+	1	2	3
		6	4	10

Reality	Prediction
-	-
+	+
+	-
-	-
-	-
+	+
-	+
-	+
-	-

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## Performance Measures

		Ideal Predictions		
		-	+	
Reality	-	7	0	7
	+	0	3	3
		7	3	10

		Actual Predictions, Example		
		-	+	
Reality	-	5	2	7
	+	1	2	3
		6	4	10

$RC = (5+2) \div 10 = 70\%$   
 $Precision = 2 \div 4 = 50\%$   
 $Recall = 2 \div 3 = 67\%$

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## Genetic programming in forecasting

EDDIE

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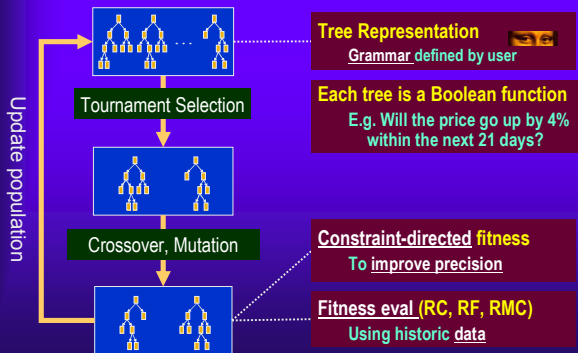
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## EDDIE Technical Overview



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Our experience

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## Our EDDIE/FGP Experience

- ◆ **Patterns exist**
  - Would they repeat themselves in the future?  
(EMH debated for decades)
- ◆ **EDDIE has found patterns**
  - Not in every series  
(we don't need to invest in every index / share)
- ◆ **EDDIE extending user's capability**
  - and give its user an edge over investors of the same caliber

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## Incentive to Improve Precision

Actual Predictions, Example

	-	+		
Reality -	75 70	5 10	80 80	
Reality +	9 5	11 15	20 20	
	84 75	16 25	100	

$$RC = (70+15) \div 100 = 85\%$$

$$Precision = 15 \div 25 = 60\%$$

$$Recall = 15 \div 20 = 75\%$$

- ◆ False positive costs real money
- ◆ We cannot change reality
- ◆ But we have control over predictions
- ◆ Hope: reduced more false positives than true positive

$$RC = (75+11) \div 100 = 86\%$$

$$Precision = 11 \div 16 = 69\%$$

$$Recall = 11 \div 20 = 55\%$$

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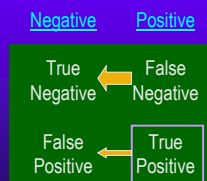
## FGP: Constrained Fitness

- ◆ Constraints can help guiding the search
- ◆  $Fitness = w_{rc} \times RC' - w_{mc} \times RMC - w_{rf} \times RF$
- ◆  $RC' = \begin{cases} RC & \text{if } P+ \in [\text{Min}, \text{Max}] \\ 0 & \text{otherwise} \end{cases}$



Jin Li  
FGP

- ◆ One can adjust Min and Max to reflect market expectation (possibly from training), or risk preference



Cautious ← Low Max

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## Experience in EDDIE on Arbitrage

- ◆ Arbitrage opportunities exist in London
- ◆ Naïve approach:
  - Monitor arbitrage opportunities, act when they arise; problem: speed
- ◆ Misalignments don't happen instantaneously
  - Do patterns exist? If so, can we recognize them?
- ◆ EDDIE-ARB can find some opportunities
  - With high confidence (precision >75%)
- ◆ Commercialisation of EDDIE-ARB
  - Need to harvest more opportunities; Need capital
- ◆ Research only made possible by close collaboration between computer scientists and economists

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## Facing scarce opportunities

Chance Discovery




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## Problem with scarce opportunities

		Predictions		
		-	+	
Reality	-	9,900	0	99%
	+	0	100	1%
		99%	1%	

Ideal prediction  
Accuracy = Precision = Recall = 100%

		Predictions		
		-	+	
Reality	=	9,800	90	99%
	≠	100	10	1%
		100%	0%	

Moves from - to +  
Randomly, accuracy = ?  
Accuracy = Precision = ?  
Precision = Recall = 1%  
(Accuracy dropped from 99%)

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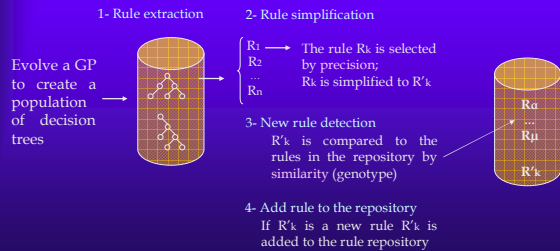
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## Repository Method

In order to mine the knowledge acquired by the evolutionary process, Repository Method performs the following steps:



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## Where does it go from here?

- ◆ **Computational finance > CI + Finance**
  - Research agenda beyond CI and finance experts
- ◆ **Finance drives computational intelligence**
  - We need more techniques for chance discovery
- ◆ **Being able to forecast alone is not sufficient**
  - If opportunity is predicted, do we invest 100%?
- ◆ **Financial forecasting is growing rapidly**
  - Conferences, IEEE Technical Committee, etc

FAQ

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## FAQ in forecasting

- ◆ **Is the market predictable?**
  - It doesn't have to be
  - But if you believe it is, you should code your own expertise
  - Market is not efficient anyway, herding has patterns
- ◆ **How can you predict exceptional events?**
  - No, we can't
  - Neither can human traders
- ◆ **How can you be sure that your program works?**
  - No, we can't
  - Neither were we sure about Nick Leeson at Barrings
  - Codes are more auditable than humans
  - If you can improve your odds from 50-50 to 60-40 in your favour, you should be happy

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## Reference

- ◆ <http://www.bracil.net/finance/papers/Tsang-Forecasting-Fcsc2009.pdf>
- ◆ Tsang, E.P.K., Forecasting – where computational intelligence meets the stock market, *Frontiers of Computer Science in China*, Springer, 2009, to appear (also filed as Working Paper WP026-08, Centre for Computational Finance and Economic Agents (CCFEA), University of Essex, revised December 2008)

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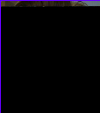







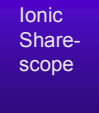
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## The Forecasting Research Team

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Ionic Share-scope

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