Michael Kampouridis
M.Kampouridis@kent.ac.uk

EDDIE for Financial Forecasting

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Contents of today's talk

- Forecasting
- Financial forecasting
  - What is it?
  - Is it possible?
  - Methods
- Computational Intelligence for financial forecasting
- EDDIE for financial forecasting
  - How it works
  - Research on EDDIE 7 and EDDIE 8
  - Latest research

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Forecasting in general

- *"Forecasting is the process of making statements about events whose actual outcomes (typically) have not yet been observed"* – Wikipedia
- Weather forecasting
- Business new product/service success forecasting
- Financial forecasting
- Other

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Financial Forecasting

- Forecast price movement of stock/market
- Forecast opportunities (buy, not-buy, sell, arbitrage)
- Forecast threats
  - Forecast scarce opportunities

Data used for forecasting

- Daily (daily closing prices)
- Intraday (high frequency)
- Volume

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Is it possible?

- Lots of debates!
- Efficient Market Hypothesis (EMH)
  - Prices fully reflect the available information that relates to the financial asset being traded
  - If EMH holds, then no point of forecasting
  - Lot of works examining the EMH from both theoretical and empirical perspective
    - Evidence both in favor of and against EMH
- "Successful" financial forecasting attempts
  - FX market, bond market, volatility forecasting, stock market crash, …

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Methods

- Fundamental analysis
  - Examine a company's financial statements and balance sheets in order to predict future trends of their shares
  - Depends on statistics, past records of assets, earnings, dividends, interest rates, sales, products, management, markets
- Technical analysis
  - Use historical data in order to predict future events
  - Belief that there are patterns in the stock prices and that these patterns repeat themselves
  - Technical indicators
    - Moving Average, Filter, Trade Break Out

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Technical Indicators: Moving Average

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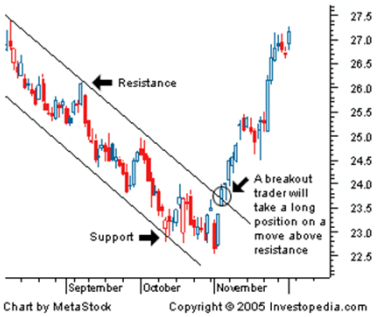
Technical Indicators: Trade Break Out



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Computational Intelligence for financial forecasting

- Artificial Neural Networks
- Genetic Algorithms
- Genetic Programming
- Grammatical Evolution
- Support Vector Machines
- Learning Classifier Systems
- Genetic Network Programming
- Differential Evolution

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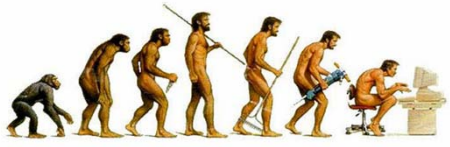
Evolution

"Evolution is the change in the inherited characteristics of biological populations over successive generations".- *Wikipedia, Article on Biological Evolution*

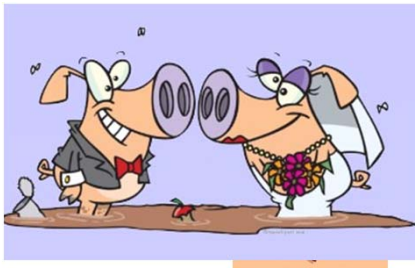


Source: http://www.managers.org.uk/practical-support/management-community/blogs/Evolution-of-Leadership-788

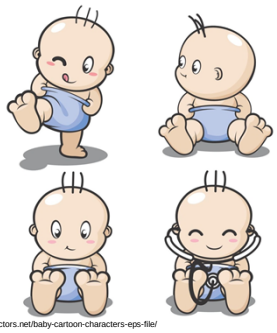
Population

Source: http://www.toonpool.com/cartoons/A%20selection%20of%20the%20population_6731

Mating



Offspring



Source: http://www.freelogovectors.net/baby-cartoon-characters-eps-file/

Survival of the fittest

Source: http://www.athleat.co.uk/eat-like-a-paleo-caveman.html

Genetic Programming

- Initialise random population of individuals/trees (in our case trading strategies)
- Evaluate each tree and assign fitness
- Select trees in order to produce new offspring by the use of different operators (e.g. crossover, mutation)
- Repeat the previous two step for a number of times ("generations")

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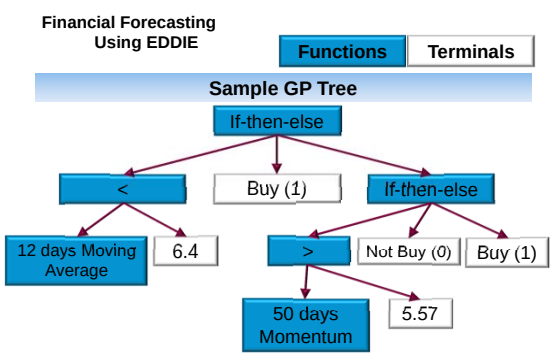

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Fitness function

- A function to measure how well a candidate solution/individual fits the data
- More about this later

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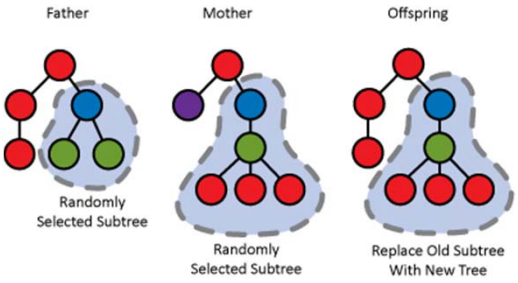
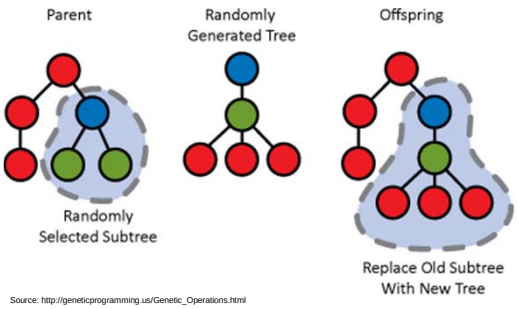
Crossover operator



Source: http://geneticprogramming.us/Genetic_Operations.html

Mutation operator



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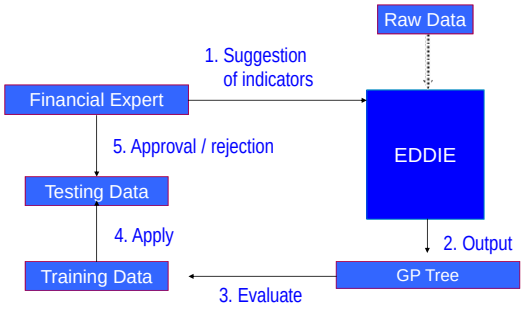
EDDIE's goal

- EDDIE is a GP tool that attempts to answer the following question:
  - "Will the price of the X stock go up by r% within the next n days"?
  - Users specify X, r, and n

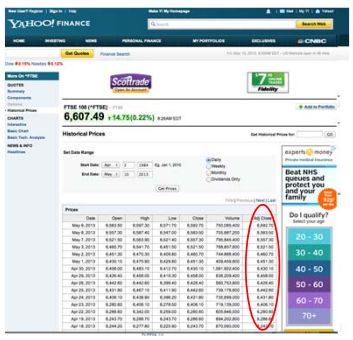
How EDDIE works



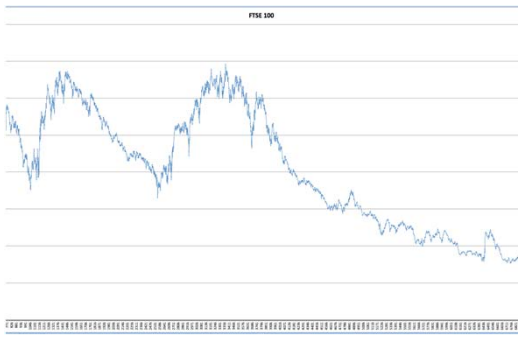
Obtaining the data

- http://finance.yahoo.com
- Datastream database (Thomson Reuters)
  - *Andy Webb, "All the data", Automated Trader, Q2 2013*
- ShareScope
- OANDA

YAHOO! FINANCE



Raw data



Technical indicators

Technical Indicator (Abbreviation)
Moving Average (MA)
Trade Break Out (TBR)
Filter (FLR)
Volatility (Vol)
Momentum (Mom)
Momentum Moving Average (MomMA)

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How the training data is created

Given	Expert adds:	More input:		Define target:
Daily closing	50 days M.A.	12 days Vol	.....	↑4% in 20 days?
90	80	50		1
99	82	52		0
87	83	53		1
82	82	51		1
.....	.....	.....		.....

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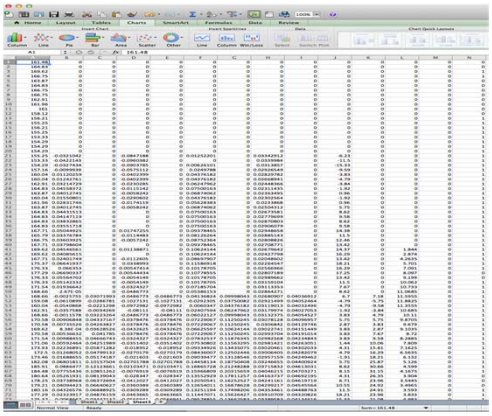

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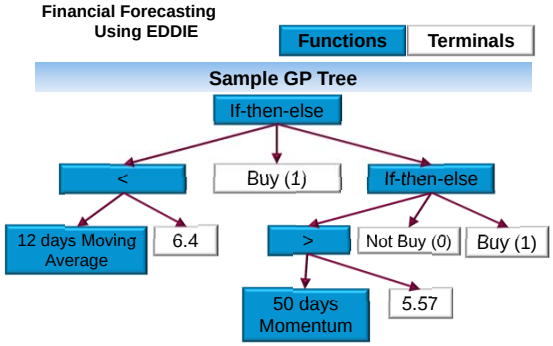

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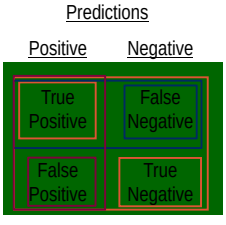
Performance Measures



- Rate of Correctness (RC) = (TN + TP) / Total
- Rate of Missing Chances (RMC) = FN / (FN+TP) [Recall = 1-RMC]
- Rate of Failure (RF) = FP / (FP + TP) [Precision = 1-RF]
- Fitness Function (ff) = w1*RC-w2*RMC-w3*RF

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Example

Assume I have a trading strategy/tree:

If
MA_12 < 81
Then
Buy (1)
Else
Not-Buy (0)

12 days Moving Average	Prediction	Target (Reality)	Classification
80	?	0	?
82	?	1	?
79	?	1	?
83	?	0	?

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12 days Moving Average	Prediction	Target (Reality)	Classification
80	1	0	FP
82	0	1	FN
79	1	1	TP
83	0	0	TN

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Example

	Fitness	Rate of Correctness (RC)	Rate of Missing Chances (RMC)	Rate of Failure (RF)
Tree 1	0.24	0.62	0.30	0.33
Tree 2	0.235	0.61	0.41	0.30
Tree 3	0.26	0.65	0.25	0.35
Tree 4	0.05	0.50	0.70	0.60
Tree 5	0.42	0.75	0.15	0.05
Average	0.24	0.626	0.362	0.326
Standard Deviation	0.13	0.08	0.21	0.195
Max	0.42	0.75	0.7	0.6
Min	0.05	0.5	0.15	0.05

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Research agenda for EDDIE 7 and EDDIE 8

- Why use technical indicators with pre-specified period length? (e.g. 12 Moving Average)
- Investigate if prediction performance (i.e. fitness) can be improved by allowing the GP to look for the optimal period length
- Allow any length between a parameterised range, e.g. 2-65 days

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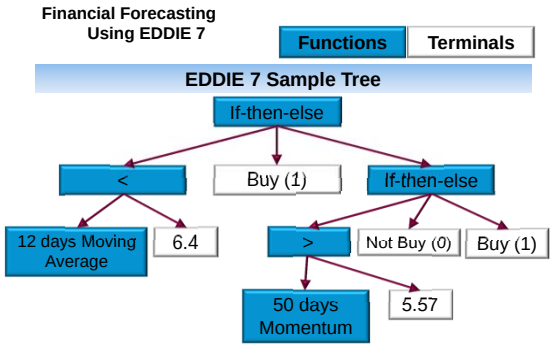

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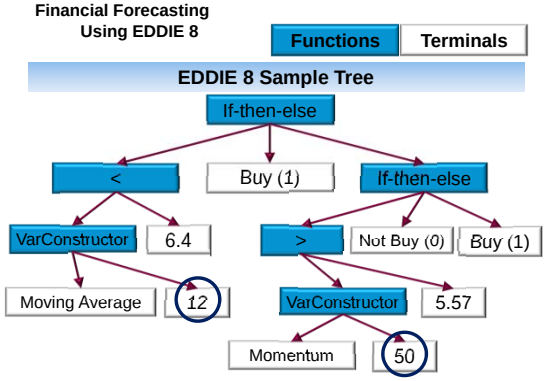
Financial Forecasting Using EDDIE 8



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Research results on EDDIE 7 vs EDDIE 8

- EDDIE 8 was able to search in the extended search space and discover new, better solutions that EDDIE 7 could not
- EDDIE 8 could not always outperform EDDIE 7
  - Trade-off between 'searching in a bigger space' and 'search effectiveness'

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Further Discussion

- Results are affected by the patterns in the datasets
  - If results come from EDDIE 8's search space, then EDDIE 8 is able to outperform EDDIE 7
  - If results come from EDDIE 7's search space, then EDDIE 8 is having difficulties in finding as good solutions as EDDIE 7 does
  - Solutions are still in EDDIE 8's search space, but they come from a very small area of it (EDDIE 7's space), and thus it is very hard for EDDIE 8 to search effectively in such a small space

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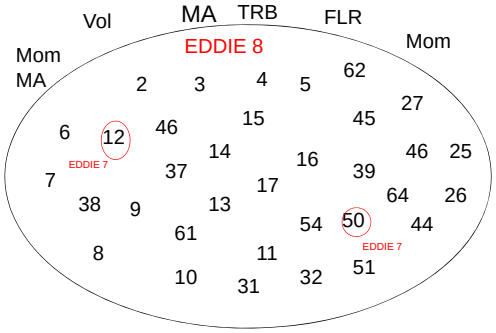
A look at search spaces…



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Meta-heuristics and hyper-heuristics for EDDIE

- Use different meta-heuristics to search in the space of the technical indicators and their periods
  - Hill climbing, Simulated Annealing, Tabu Search, Guided Local Search, …..
  - Use EDDIE 8 with any of the above meta-heuristics
- Combine successful meta-heuristics into different frameworks: hyper-heuristics

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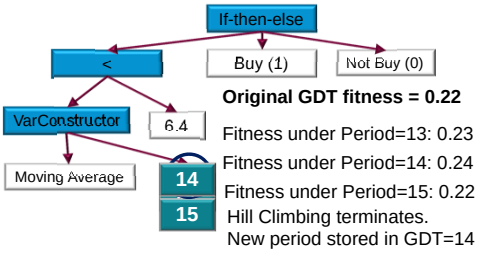
Heuristics

Example of Iterative Hill Climbing



Original GDT fitness = 0.22

Fitness under Period=13: 0.23
Fitness under Period=14: 0.24
Fitness under Period=15: 0.22
Hill Climbing terminates.
New period stored in GDT=14

Hill Climbing for 3 periods

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Results

Simulated Annealing

Significantly improved: 27
Significantly worsened: 7

Dataset	Heuristic	Fitness	RC	RMC	RF
Barclays	Original	0.3633	0.7100	0.2449	0.0411
	S.A.	**0.4350**	**0.8167**	**0**	0.0541
BAT	Original	0.3303	0.6667	0.2780	0.1083
	S.A	**0.3690**	**0.7433**	**0**	**0**
Cadbury	Original	0.3685	0.7533	0.1341	0.2131
	S.A.	0.3733	0.7600	**0**	0.2179
Imp Tob	Original	0.2802	0.6367	0.3946	0
	S.A.	**0.2929**	**0.6533**	**0**	0
Schroders	Original	0.2369	0.6100	0.2333	0.2456
	S.A	**0.3054**	**0.6800**	**0**	**0.1780**
Sky	Original	0.2066	0.6800	0.5922	0.4222
	S.A.	**0.3059**	**0.6967**	**0**	**0**

Sample BEST Results for SA

BETTER WORSE

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Results

Tabu Search

Significantly improved: 31
Significantly worsened: 4

Dataset	Heuristic	Fitness	RC	RMC	RF
Barclays	Original	0.3633	0.7100	0.2449	0.0411
	T.S.	**0.4350**	**0.8167**	**0**	0.0392
BAT	Original	0.3303	0.6667	0.2780	0.1083
	T.S.	0.3323	**0.6900**	**0.2287**	**0**
Cadbury	Original	0.3685	0.7533	0.1341	0.2131
	T.S.	**0.3817**	**0.7700**	**0**	**0.1928**
Imp Tob	Original	0.2802	0.6367	0.3946	0
	T.S.	**0.2989**	**0.6567**	**0.0541**	0
Schroders	Original	0.2369	0.6100	0.2333	0.2456
	T.S.	**0.2815**	**0.6567**	**0.0444**	0.2429
Sky	Original	0.2066	0.6800	0.5922	0.4222
	T.S.	**0.3207**	**0.7000**	**0.1165**	**0**

Sample BEST Results for TS

BETTER WORSE

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Results

Guided Local Search

Significantly improved: 35
Significantly worsened: 3

Dataset	Heuristic	Fitness	RC	RMC	RF
Barclays	Original	0.3633	0.7100	0.2449	0.0411
	GLS	**0.4350**	**0.8167**	**0**	**0.0260**
BAT	Original	0.3303	0.6667	0.2780	0.1083
	GLS	**0.3690**	**0.7433**	**0**	**0**
Cadbury	Original	0.3685	0.7533	0.1341	0.2131
	GLS	**0.4153**	**0.8067**	**0**	**0.1897**
Imp Tob	Original	0.2802	0.6367	0.3946	0
	GLS	**0.3197**	**0.6767**	**0**	0
Schroders	Original	0.2369	0.6100	0.2333	0.2456
	GLS	**0.2909**	**0.6700**	**0**	**0**
Sky	Original	0.2066	0.6800	0.5922	0.4222
	GLS	**0.2214**	0.6733	**0**	**0.4706**

Sample BEST Results for GLS

BETTER WORSE

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Overall results

- Meta-heuristics made the search more effective
- Seem to have good generalization, as they introduced improvements to all datasets
- GLS was the most effective meta-heuristic from the ones tested (Smonou, 2012)
  - Trade-off: slowed down the runtime of the algorithm
- Improvements in the GLS performance (Shao, 2013)
  - Improved the predictive performance of the algorithm
  - Implemented Fast Local Search, which made the GLS 80% faster

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Meta-heuristics and hyper-heuristics for EDDIE

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Hyper-heuristics for EDDIE 8

- Combine many meta-heuristics into a hyper-heuristics framework
- Other ways of selecting the heuristics exist
  - A lot of research in looking for 'good' hyper-heuristic frameworks
- Best-so-far framework:
  - Select which meta-heuristic to use based on:
    - How well a given heuristic has performed individually
    - How well a given heuristic has performed as a successor of a previously invoked heuristic
    - The elapsed time since the heuristic was called
- The above method is called the Choice Function

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Results on hyper-heuristics

- Overall improvement of the algorithm's predictive performance
- Hyper-heuristics had the ability to decide which meta-heuristic is more effective at **a given time**, and apply it to the trees of the population
- Hyper-heuristics would select different meta-heuristics based on **the dataset being used**

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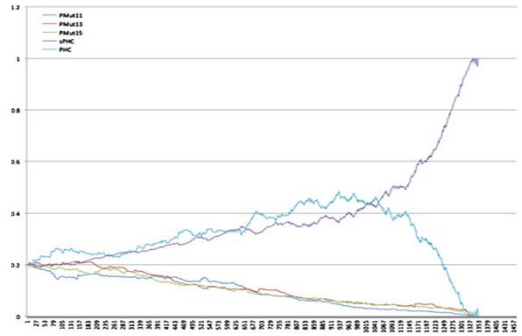

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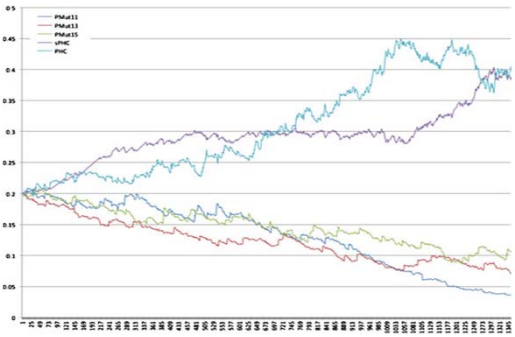

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More research on Hyper-heuristics: Choice Function

- Hyper-heuristics with Choice Function made EDDIE 8 the most successfully algorithm of the EDDIE series (Aluko, 2013)

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Conclusion

- Financial forecasting
- EDDIE
- Results on EDDIE 8
- Meta- and hyper-heuristics for EDDIE 8

Where to next?

- Directional changes
- Research on parallelization, e.g. GPU (Graphics Processing Unit) cards

EDDIE available to download

- ZIP file available at http://www.kampouridis.net/teaching/cf963/

Thank you!

- Questions?