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Towards machine pricing

Pietro Parodi, Swiss Re

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Agenda

Follow-up on "**Computational intelligence** techniques with applications to general insurance: a review. I – The role of **statistical learning**"… *after big data, InsurTech, deep learning*

Three main contentions:

A. Machine learning is not something to turbo-speed actuarial modelling – it is **the right approach to modelling**, big N and small N alike

B. Machine learning is the natural pathway to **costing automation**, including judgment

C. AI may also provide the tool (**reinforcement learning**) to address a more difficult problem, that of making strategic decisions such as **pricing**

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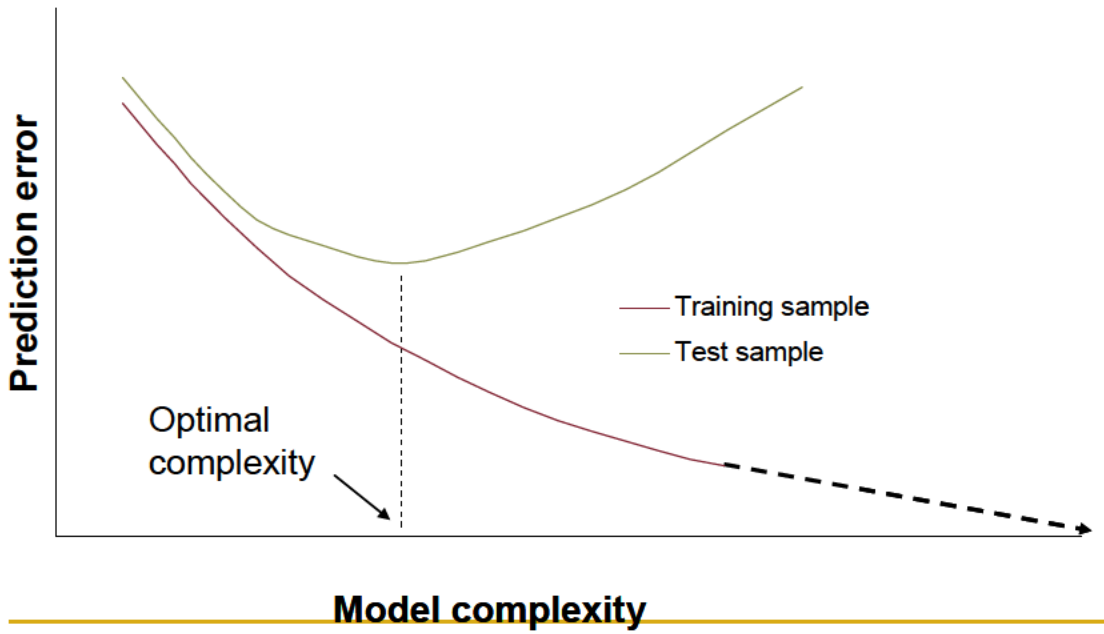
A. Machine learning provides a sound theory of modelling

- *Experience rating* is an example of supervised learning, i.e. predictive models from data
- ML provides a clear framework for building models with the lowest prediction error (not only personal lines!)



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B. What can be automated?

Big Data

Submission data

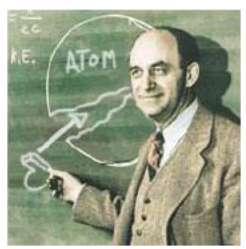
Methods

- MLE
- Monte Carlo
- EVT
- GLM
- Lasso regression
- ...

Data preparation and modelling

Expected cost of risk

Actuarial judgment



Theory-building

Past examples

Knowledge base (theory and facts)

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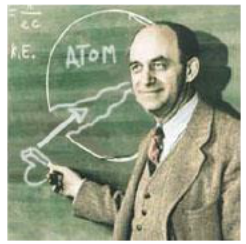
B. What can be automated?

Big Data

Submission data

Methods

- MLE
- Monte Carlo
- Extreme value theory
- GLM
- Lasso regression
- ...



Theory-building

Data preparation and modelling

Sparse data - Smart combination of theory and data (e.g. EVT)

Automation of data exploration and preparation (NLP, etc.)

Efficient automation of rating factors

Smart use of portfolio data in F/S modelling

Actuarial judgment

Expected cost of risk

Past examples

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B. What can be automated?

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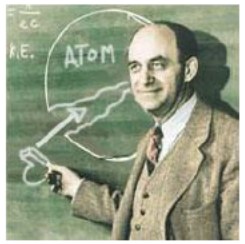
Data preparation and modelling

Expected cost of risk

Actuarial judgment

How long does it take **you** to develop good judgment?



Theory-building

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Knowledge base (theory and facts)

Past examples

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B. A pathway to machine costing – What it allows to do

- Increased number of actuarial investigations [relevant to our future!]
- Improved portfolio management through bots
- **Unbiased risk costing** and the clear-cut separation between pure cost and underwriting/actuarial adjustments

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C. Towards machine *pricing*

- What supervised learning does for risk costing, reinforcement learning does for pricing and (in general) making decisions in a (partially unknown) environment
- Reinforcement learning is at the core of the science of making decisions
  - *Engineering*: optimal decisions; *neuroscience*: reward system; *psychology*: conditioning
  - Examples: fly stunt maneuvers in a helicopter, backgammon, controlling a power station, **playing Atari games**
- Main differences with supervised learning:
  - no supervision – only a reward signal
  - feedback is delayed
  - agent's actions affect the subsequent data it receives

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C. Towards machine *pricing* – Reinforcement learning

The agent

O_t

observation (premiums in, claims out)

A_t

action (rate change)

R_t

estimated reward (profit)

The environment

(loss distribution, demand curve, competitors…)

Very much like the dopamine-based reward system in the brain!

Problems/limitations

- Solutions can only be approximate, and the problem is NP-complete
- Large rare events make it difficult to calculate expectations
- In long-tail business, information about the environment may be collected too slowly…
- … and may age too quickly
- The environment is not just a "blur" but is made of other agents
- Exploration vs exploitation – a delicate balance

These problems are not unique to machines!

A separate issue

You may get very different results if the agent is a single underwriter *vs* an insurance company!

Objective: maximise cumulative rewards/utilities $U([t_0, t_1 \dots t_n, \dots]) = \sum_{i=0}^{\infty} \gamma^i R_{t_i}$

Mathematical framework: [partially observable] Markov decision processes

Example of technique: dynamic Bayesian networks

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Recapping… three main (proposed!) takeaways

A. Actuaries should learn machine learning not only to be *à la page* or to address Big Data but to be more rigorous in their modelling work

B. Machine learning's biggest contribution will be as a help to automate the rating process, *including much of actuarial judgment*

C. Reinforcement learning is the right framework for looking at a more difficult problem, that of making a commercial pricing decision

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GLOSSARY

AI-complete problem = a problem which is at least as difficult as that of producing an agent which exhibits general human intelligence

Bot = a piece of software that performs tasks on behalf of a user

Computational intelligence = a bashful term for artificial intelligence

Deep learning = a type of supervised/unsupervised learning based on many-layered artificial neural networks, allowing for a considerable abstraction in data representation

Dynamic Bayesian network = a methodology to find optimal solutions for POMDPs

Lasso regression = a regression method that can be used to select a model with the right rating factors automatically

Machine costing = the setting of the technical premium in an automated way

Machine pricing = the setting of the actual (commercial) premium in an automated way

Markov decision process (MDP) = a mathematical framework for decision making in a (fully known) stochastic environment

Natural language processing = a field of AI concerned with enabling machines to extract meaning from human language inputs

NP(non-deterministic polynomial)-complete = a problem for which no solution can (probably) be found in polynomial time – but which has a succinct certificate: i.e. the goodness of a proposed solution can be tested in polynomial time

Partially observable Markov decision process (POMDP) = a mathematical framework for decision making in a (partially known) stochastic environment

Reinforcement learning = making effective decisions by an appropriate reward system, e.g. dopamine-based system in the brain

Statistical learning = a bashful term for machine learning

Supervised learning = building predictive models by training algorithm with past examples/data

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REFERENCES – 1 of 2

On machine learning as a sound theory of modelling:

- Parodi (2012a), *Computational intelligence with applications to general insurance: A review. I – The role of statistical learning*, Annals of actuarial science
- Parodi (2014), *Pricing in General Insurance*, CRC Press [Chapter 12 – What is this thing called modelling?]

On job automation:

- Frey and Osborne (2013), *The future of employment: how susceptible are jobs to computerization?*
- Arntz et al. (2016), *The risk of automation for jobs in OECD countries*

On reinforcement learning (and POMDPs) as the next step beyond machine learning as a framework for making decisions:

- Parodi (2012b), *Computational intelligence with applications to general insurance: A review. II – Dealing with uncertainty*, Annals of actuarial science

General references:

- Russell and Norvig (2013), *Artificial Intelligence: A Modern Approach*, 3rd Edition, Prentice Hall
- Bishop (2007), *Pattern recognition and machine learning*, Springer
- Hastie, Tibshirani and Friedman (2009), *The Elements of Statistical Learning,* 2nd Edition, Springer

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REFERENCES – 2 of 2

Recent papers on machine learning in insurance

- Chalk (2016), *A practical introduction to machine learning concepts for actuaries,* CAS E-Forum (Spring)
- Ward (2015), *Penalised regression,* GIRO Proceedings

Soft reads

- Argesanu et al. (2016), *Everything that you can do, AI can do better,* Insurance Nexus
- IA/BE (2015), *Big data: an actuarial perspective*, Institut des Actuaires en Belgique
- “Special report: Artificial Intelligence”, The Economist, June 25th 2016
- "I'm afraid I can't do that", The Economist, June 4th 2016
- Parodi (2010), *From artificial fish to underwriters*, The Actuary (March)
- Parodi (2016), *Towards machine pricing*, The Actuary – Technology supplement (September)

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Questions

Comments

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

The views expressed in this presentation are those of the presenter.

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