Institution: Robert Gordon University

Unit of Assessment: 11 Computer Science and Informatics

Title of case study: Optimised Retrieval for Reusing Insurance Underwriting Cases

1. Summary of the impact (indicative maximum 100 words)

Case Based Reasoning (CBR) is well suited to decision support in weak theory domains where important influences and interactions are not well understood. CBR retrieves and reuses similar cases that capture previous decisions, without reasoning about why/how the decision was made. Research at RGU has developed introspective learning technologies to capture knowledge that provides effective case retrieval and reuse in case-based systems. This self-optimised introspective CBR is embedded in a significantly changed process for insurance underwriting at Genworth Financials. Self-optimising retrieval selects relevant cases from Genworth's library of previous insurance cases, to be reused to assist decision-making of underwriters. The manual underwriting process is improved by increasing the consistency of underwriting decisions. Furthermore a 40% improvement in productivity is achieved for handling new insurance customers.

2. Underpinning research (indicative maximum 500 words)

Our research track record developing machine learning techniques for automated knowledge acquisition and refinement has been established over 20 years. Since 1997 this research has focused on case-based decision support systems, where similar cases are retrieved from memory, and reused to create solutions to new problems [**R1**].

An EPSRC project (GR/L98015/01) developed an automated knowledge engineering system that transforms a database of solved cases into a fully-fledged Case Based Reasoning (CBR) system. The target application for this collaboration with Ray Rowe (AstraZeneca) was pharmaceutical product design. Applied to tablet design, this research successfully replicated, *automatically*, knowledge engineering results for a case-based system that were expensive to achieve manually for rules [**R2**]. There are two main outcomes of this project.

- ***Self-Optimising Retrieval:*** Introspective learning techniques based on genetic algorithms were developed to achieve knowledge acquisition from the cases themselves. The similarity knowledge that was extracted enables the retrieval of relevant cases for problem solving **[R3]**. The introspective nature of the learning - from the cases that represent the problem-solving domain - means that the optimisation of retrieval of cases is tailored to the domain and offers the opportunity for self-optimising retrieval [**R4**].
- ***Introspective CBR:*** The introspective approach from self-optimising retrieval is replicated for the full reasoning cycle of CBR. A collection of cases is transformed into a case-based decision support system in which the case-based reasoning is tuned using new knowledge extracted from the cases themselves [**R4, R5, R6**]. Introspective learning may also be used to update the reasoning knowledge when the problem-solving domain changes; e.g. when the policy changes on which ingredients are available to choose from as fillers and binders in tablet formulations [**R2**].

Case-based methods are inherently evidence-based because they exploit the evidence from individual cases. The introspective learning in Self-Optimising Retrieval and Introspective CBR enables the evidence in cases to tailor the reasoning also, so that decision support is truly evidence-based, through reasoning as well as cases.

Key Researchers

Susan Craw: Lecturer/Senior Lecturer/Reader/Professor (1983->)

Nirmalie Wiratunga: Masters/PhD student (1996-2000), Research Fellow/Lecturer/Reader (2001->)

Jacek Jarmulak: Research Fellow (1998-2001). *Since then at Ingenuity Systems, CA (2001-2006) and then Chief AI Scientist, now VP Product Development, at Resolvity Inc, TX, (2006->).*

3. References to the research (indicative maximum of six references)

Key references are marked with an asterisk

[**R1**] Susan Craw, Nirmalie Wiratunga, and Ray Rowe (1998). Case-based design for tablet formulation. In *Advances in Case-Based Reasoning, Proceedings of the 4th European Workshop*, LNCS 1488, pp 358-369. Springer. doi: 10.1007/BFb0056347 *[49 Google Scholar citations (15 self)]*

[**R2**]* Susan Craw, Jacek Jarmulak, and Ray Rowe (2001). Maintaining retrieval knowledge in a case-based reasoning system. *Computational Intelligence*, 17(2):346-363. doi: 10.1111/0824-7935.00149. *Impact Factor: 1.415.* *[31 Google Scholar citations (8 self)]*

[**R3**] Jacek Jarmulak, Susan Craw, and Ray Rowe (2000). Genetic algorithms to optimise CBR retrieval. In *Advances in Case-Based Reasoning, Proceedings of the 5th European Workshop*, LNCS 1898, pp 136-147. Springer. doi: 10.1007/3-540-44527-7_13 *[65 Google Scholar citations (11 self)]*

[**R4**]* Jacek Jarmulak, Susan Craw, and Ray Rowe (2000). Self-optimising CBR retrieval. In *Proceedings of the 12th IEEE International Conference on Tools with Artificial Intelligence*, pp 376-383. IEEE Press. doi: 10.1109/TAI.2000.889897. *Shortlisted for Best Paper Award 30% Acceptance.* *[53 Google Scholar citations (3 self)]*

[R5]* Jacek Jarmulak, Susan Craw and Ray Rowe (2001). Using case-base data to learn adaptation knowledge for design. In *Proceedings of the 17th International Joint Conference on Artificial Intelligence (IJCAI)*, pp 1011-1016. Morgan Kaufmann. http://ijcai.org/Past%20Proceedings/IJCAI-2001/content/content.htm
24% acceptance. *[41 Google Scholar citations (9 self)]*

[**R6**] Susan Craw, Nirmalie Wiratunga, and Ray C. Rowe (2006). Learning adaptation knowledge to improve case-based reasoning. Artificial Intelligence, 170(16-17):1175-1192, 2006. doi: 10.1016/j.artint.2006.09.001*. Impact Factor 2.271. In ScienceDirect's Top25 AI hotlist: 4th in Oct-Dec 2006, 11th in Jan-Mar, 21st in Apr-Jun 2007.* *[65 Google Scholar citations (6 self)]*

Research Grants

EPSRC GR/L98015/01, Easing Knowledge Acquisition for Case-Based Design, PI Susan Craw, 1998-2002, £152k. PDRAs: Jacek Jarmulak and then Nirmalie Wiratunga. Industry collaborator: Ray Rowe, AstraZeneca

EPSRC's peer-assessed review judged this research to be "tending to internationally leading" and overall to be "tending to outstanding".

4. Details of the impact (indicative maximum 750 words)

Context

"Insurance underwriters evaluate the risk and exposures of potential clients. … Underwriting involves measuring risk exposure and determining the premium that needs to be charged to insure that risk. … Each insurance company has its own set of underwriting guidelines to help the underwriter determine whether or not the company should accept the risk. The information used to evaluate the risk of an applicant for insurance will depend on the type of coverage involved. … Depending on the type of insurance product, insurance companies use automated underwriting systems to encode these rules, and reduce the amount of manual work in processing quotations and policy issuance. This is especially the case for certain simpler life or personal lines insurance." [Wikipedia: Insurance Underwriting]

"Insurance underwriting is a complex decision-making task traditionally performed by trained individuals. … Specializing to life insurance, there is a natural dichotomy in applicants - those who have medical impairments (such as hypertension or diabetes) and those who do not (who are "clean"). Clean case underwriting is relatively simple and we have been able to represent it by a compact set of fuzzy logic rules. Impaired underwriting is more difficult, as the applicant's medical data is more complex. Underwriters thus use more judgment and experience in these cases. Therefore, rather than create an enormous and un-maintainable fuzzy rule base, we turned to CBR to handle the impaired cases." **[I1** p15**].**

Genworth Financial, a spin-off from the insurance business of GE, is one of the largest insurance and financial services holding companies in the U.S. Its GENIUS™ digital underwriting tool exploits previous insurance cases to underpin the decision support it provides to assist human underwriters assess life and health insurance applications.

Pathway to Impact

Our introspective learning methods had been well publicised at International and European CBR conferences and IJCAI during the period 2000-2002 including [R3,R5]. These conferences were attended by CBR researchers from GE Global Research working on innovative applications of AI. Our generic GA-based Self-Optimising Retrieval [R1,R5] inspired the evolutionary approach to tuning CBR parameters in General Electric's SOFT-CBR tool [**I1**]. Our work was explicitly credited during the SOFT-CBR presentation at the 5th International Conference on Case-Based Reasoning [**I2**]. One particularly successful application of SOFT-CBR was GE's Digital Underwriting Tool for automating the underwriting of insurance applications [**I1-I4**].

In order to protect IP associated with **Self-Optimising Retrieval** for insurance underwriting, GE filed the patent *Process for case-based insurance underwriting* (November 2010)**:**

"*A process for at least a partial underwriting of insurance policies is described. Based on the similarity to previous insurance applications, a decision on the current request for underwriting may be made. This decision-making process represents an analogical approach to the placement of an insurance application to an underwriting category, whereby a given insurance application request is compared to previous requests.*" [**I5**].

This was extended beyond retrieval to **Introspective CBR**, together with a similar introspective learning for fuzzy rules, with the patent *Process for optimization of insurance underwriting* (March 2011):

"*A robust process for automating the tuning and maintenance of decision-making systems is described. A configurable multi-stage mutation-based evolutionary algorithm optimally tunes the decision thresholds and internal parameters of fuzzy rule-based and case-based systems that decide the risk categories of insurance applications. The tunable parameters have a critical impact on the coverage and accuracy of decision making, and a reliable method to optimally tune these parameters is critical to the quality of decision-making and maintainability of these systems.*" [**I6**]

In all, 16 US patents have been granted for the Digital Underwriting Tool [**I7**].

Genworth Financial was spun off from GE's insurance business in the largest IPO of 2004, for $2.8 billion. At the time of the IPO, stock analysts specifically cited digital underwriting as one of the key advantages Genworth has over its competitors. The patents played a critical role in the valuation of Genworth [**I3, I4, I8**].

Reach and Significance

Genworth is now one of the largest insurance and financial services holding companies in the U.S. It is a Fortune 500® company with more than $100 billion in assets, $1-5 billion revenue, 6000 employees, and a presence in more than 25 countries [**I9**].

At Genworth, the digital underwriting tool is now called GENIUS™, and is the responsibility (from an underwriting standpoint) of the Chief Underwriter [**I10**]. GENIUS™ sets up the cases for the underwriters and new business associates, receives requirements, and manages work. When a new case is received, GENIUS™ walks the application through the underwriting process, alerting the underwriters and new business associates to relevant tasks. The use of GENIUS™ within Genworth is significant; it processes all life insurance applications - currently 2000 per week.

Although a digital underwriting tool might be expected to provide decision-making, by proposing insurance solutions automatically, only 3-4% of Genworth's applications are processed automatically, and an underwriter nevertheless still touches all these cases. Instead the main purpose of GENIUS™ is to provide decision support to the underwriters by suggesting a course of action, highlighting issues that should be taken into account, and proposing solutions. As a tool supporting human underwriters, it is important that its assistance is evidence-based; i.e. captured from previous insurance cases. GENIUS™ uses evidence from 9 years worth of insurance cases.

One of the main advantages is how it presents information to the underwriters. For example when laboratory data is received, GENIUS™ makes a first pass at evaluation by highlighting to the underwriter things that are abnormal and things that should be checked; e.g. when blood test results are received; perhaps check liver enzymes. In this way GENIUS™ provides relevant information about the case being considered to the underwriter and helps the underwriter make sound decisions.

The biggest advantage of GENIUS™ is in Genworth's New Business department, where a 40% improvement in productivity was achieved. The impact of GENIUS™ for underwriting in general is in improved consistency, and for underwriting, consistency is very important. There is no empirical evidence of the improvement in consistency, but the decision support that GENIUS™ provides is repeatable in what it flags as normal/abnormal, and this influences the subsequent decision-making.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[I1] K. S. Aggour, M. Pavese, P. P. Bonissone & W. E. Cheetham, SOFT-CBR: A Self-Optimizing Fuzzy Tool for Case-Based Reasoning, *Proceedings of the 5th International Conference on Case Based Reasoning*, LNCS 2689, pp5-19, Springer, 2003. doi: 10.1007/3-540-45006-8_4

[I2] Senior Computer Scientist, GE Global Research. Letter confirming the relationship between the underpinning research and GE's SOFT-CBR system, and the development of the Digital Underwriting Tool at GE.

[I3] K. S. Aggour, P. P. Bonissone, W. E. Cheetham and R. P. Messmer, Automating the Underwriting of Insurance Applications, *AAAI AI Magazine* 2(3):36-50, 2006. A special issue on selected papers from Innovative Applications of Artificial Intelligence.

[I4] Chief Scientist, GE Global Research. Letter confirming development of the Digital Underwriting Tool at GE, the related patents, and the importance of the patents in the valuation of the financial business at spinoff.

[I5] Patent No US 7844476 (30 November 2010) *Process for case-based insurance underwriting suitable for use by an automated system*. P. Bonissone, R. Messmer, D. Yang, M. Pavese, A. Patterson, A. Mogro-Campero, A. Varma, W. Durham, D. Russel, and R. Subbu. Assignee: Genworth Financial Inc.

[I6] Patent No US 7899688 (1 March 2011) *Process for optimization of insurance underwriting suitable for use by an automated system*. P. Bonissone, R. Messmer, A. Patterson, D. Yang, M. Pavese, R. Subbu, and K. Aggour. Assignee: Genworth Financial Inc.

[I7] http://www.patentgenius.com/assignee/GenworthFinancialInc.html (Accessed 4 November 2013)

[I8] Greg N. Gregoriou, *Initial Public Offerings (IPO): An International Perspective of IPOs, page 131*. Elsevier ISBN 978-0750679756. http://books.google.co.uk/books?id=c_0XpImakTIC&pg131 (Accessed 4 November 2013)

[I9] https://www.genworth.com/corporate/about-genworth.html (Accessed 4 November 2013)

[I10] Senior VP Underwriting and Chief Underwriter, Genworth Financial Inc. Letter describing GENIUS™ at Genworth and its impact on underwriting.