REF2021

Institution: City, University of London

Unit of Assessment: Computer Science

Title of case study: A Machine Learning system to predict and help mitigate problem gambling.

Period when the underpinning research was undertaken: 2014 - present

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Artur GARCEZ	Professor	2002 – present
Tillman WEYDE	Senior Lecturer	2005 – present
Gregory SLABAUGH	Senior Lecturer	2012-12/2017

Period when the claimed impact occurred: 2014 - 2020

Is this case study continued from a case study submitted in 2014? N

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

City's partnership with BetBuddy has created a fully explainable analytics platform to help identify and reduce problem gambling. In 2017, the system was acquired by Playtech and this technology currently supports 9 gambling platforms used by approximately 3 million registered gamblers worldwide.

The research has helped the gambling industry meet increasingly stringent regulation, and enabled individuals to gamble more securely and responsibly online. The team are at the forefront of public engagement in responsible gambling and have attracted widespread media attention for their research. More recently the research partnership has evolved to explore how big data might help prevent money-laundering within the gambling industry.

2. Underpinning research (indicative maximum 500 words)

Rapid growth in global online gambling has seen a rise in vulnerable gamblers in many countries. A strategic partnership between City academics (Garcez, Weyde and Slabaugh) and UK Start-Up BetBuddy has developed a novel solution: explainable machine learning models capable of predicting problem gambling behaviour – a unique development within the industry.

Building on Garcez' earlier work on the 'explanation capability' of neural networks [3.6], and drawing on the analysis of online casino gambling data [3.4], City's former Research Centre for Machine Learning (ML) began a dynamic research partnership with BetBuddy in 2014 as part of Innovate UK/EPSRC funded research projects to better understand how AI might help in the prevention of problem gambling (see Section 3, Indicators of quality of the underpinning research).

Their first study analysed the performance of supervised machine learning models to predict online gambling 'self-exclusion' [3.1]. From a sample of 845 online gamblers, four ML models were evaluated empirically. The Random Forest technique was found to be the most effective method for prediction, achieving an accuracy improvement of 35% versus baseline estimates.

Further research began by testing industry requirements for potential models. This revealed the criticality of 'explainable' models, both to help the user interact with the gambler, and to recommend interventions. These insights were crucial: current machine learning methods may offer good prediction performance, but their effectiveness is limited by the machine's failure to explain its decisions to users. [3.2]

In pursuit of explainable models, City's research team (Garcez, Weyde and Slabaugh as academics and Manoel Franca, Research Associate on the project França) tested a variant of the knowledge extraction algorithm TREPAN which, when given a neural network trained on gambling data, was able to produce compact, human-readable logic rules. The results converted a 500+ parameter neural network model into a 9 route decision tree with only a 1% loss of model accuracy. This original research was the first to report an industrial-strength application of knowledge extraction from neural networks in gambling protection from harm. [3.2]

Additional research produced the first comparative evaluation of predictive performance and tree properties for extracted trees from neural networks and Random Forest models, which was also the first comparative evaluation of knowledge extraction for safer gambling [3.3]. The results confirmed that Random Forests performed better than neural networks on this type of data – with 87% accuracy – and that both methods outperformed a standard decision tree on cross-validated accuracy.

These findings underpin the current BetBuddy system: Random Forests are trained on historical data such as play intensity variation, frequency, deposits and withdrawals – in combination with an existing BetBuddy rule-based system – to predict whether a player should be classified as a "self-excluder". Analytics are automatically fed back to the operator and player. Operators can then make interventions, such as tailored marketing strategies, while players receive auto-generated personalised communications and a series of choices from the operator's existing player protection tools. The regulator can also access the explanations of the system for audit purposes.

Several MSc internship projects took place in collaboration with BetBuddy, including Sanjoy Sarkar, MSc in Data Science at City and co-author of some of the papers, who was later hired by BetBuddy. City also secured a PhD studentship, in collaboration with BetBuddy's CEO Simo Dragicevic, which was 100% funded by industry. The partnership between City and BetBuddy has recently evolved to include a collaboration with Kindred Group, one of the largest online gambling groups, to explore using AI techniques to detect suspicious gambling and money laundering. The research collaboration also continues, with the most recent publication investigating the timely issue of fairness and gender bias in the use of AI for gambling in collaboration also with BetBuddy's chief data scientist Percy [3.5].

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

3.1 Percy, C., França, M., Dragičević, S., & d'Avila Garcez, A. (2016). Predicting online gambling self-exclusion: an analysis of the performance of supervised machine learning models. *International Gambling Studies*, *16*(2), 193-210. DOI: https://doi.org/10.1080/14459795.2016.1151913
3.2 Percy, C., d'Avila Garcez, A. S., Dragičević, S., França, M. V., Slabaugh, G., & Weyde, T. (2016, August). The need for knowledge extraction: understanding harmful gambling behavior with neural networks. In *Proceedings of the Twenty-second European Conference on Artificial Intelligence* (pp. 974-981). IOS Press. DOI: https://doi.org/10.3233/978-1-61499-672-9-974. Permanent repository link: http://openaccess.city.ac.uk/id/eprint/16483/
3.3 Sarkar, S., Weyde, T., d'Avila Garcez, A., Slabaugh, G. G., Dragicevic, S., & Percy, C. (2016, December). Accuracy and interpretability trade-offs in machine learning applied to safer gambling. In *CEUR Workshop Proceedings* (Vol. 1773) at NIPS. CEUR Workshop Proceedings. Accessible at: http://ceur-ws.org/Vol-1773/CoCoNIPS_2016_paper10.pdf Permanent repository link: https://openaccess.city.ac.uk/id/eprint/16484

3.4 Dragičević, S., Percy, C., Kudic, A., & Parke, J. (2013). A Descriptive Analysis of Demographic and Behavioral Data from Internet Gamblers and Those Who Self-exclude from Online Gambling Platforms. *Journal of Gambling Studies*, 1-28. https://link.springer.com/article/10.1007%2Fs10899-013-9418-1

3.5 Percy, C., d'Avila Garcez, A., Dragicevic, S., Sarkar, S. (2020). Lessons Learned from Problem Gambling Classification: Indirect Discrimination and Algorithmic Fairness. *AAAI Fall Symposium*, Washington, USA, AAAI Press.

3.6 Garcez, A., Broda, K. and Gabbay, D. M. (2001). Symbolic knowledge extraction from trained neural networks: A sound approach. *Artificial Intelligence*, 125(1-2), pp. 153-205 https://www.sciencedirect.com/science/article/pii/S0004370200000771?via%3Dihub Permanent repository link: https://openaccess.city.ac.uk/id/eprint/293

Indicators of quality of the underpinning research
Three outputs were published in prestigious academic journals which apply a rigorous peer-review process prior to acceptance of papers. Three others were presented at international conferences which also which apply a rigorous peer-review process prior to acceptance of papers.

The research was supported by two grants:
EPSRC grant EP/M50712X/1 (£104,938) led by City, University of London (Oct 14 - Dec 15) https://gtr.ukri.org/projects?ref=EP%2FM50712X%2F1
UK Research and Innovation grant 101928 (£174,365) led by BetBuddy with participation of City, University of London (Oct 14 - Jan 16) https://gtr.ukri.org/projects?ref=101928

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

In effort to reduce gambling harms, all UK gambling providers are legally obliged to offer customers a self-exclusion option as one of preventative measures. City's research has directly impacted BetBuddy's ability to provide operators with an effective predictor for self-exclusion and other signals that indicate problem gambling. This enables gambling operators, the main beneficiary of the BetBuddy system, to identify problem gambling early, which in turn currently enables approximately 3 million registered gamblers worldwide [5.1] to use online gambling platforms more securely and responsibly.

Practical contribution to responsible gambling efforts
City's research directly led to the development of PowerCrunch, BetBuddy's core data mining and machine learning platform. It is available either as Software as a Service (SaaS) or as a product that can be seamlessly integrated with player account management systems, content management systems, and eCRM systems.

BetBuddy's CEO, Simo Dragicevic, explains, "*Together, we developed a system capable of identifying harmful play and assisting in reducing at-risk gambling*" [5.1]. "*City has enabled us to build more robust and accurate prediction models and apply new, creative algorithms to gambling data. By applying their expertise in knowledge extraction techniques to 'black box' prediction models, clinicians, regulators, and industry can better understand how these models can predict behaviour and better protect consumers at risk of harm.*" [5.2]

Since 2014, 300 000 registered users of the Ontario Lottery and Gaming Corporation (OLG), a holder of a government mandate to work towards a 'Gold Standard' in Responsible Gambling (RG), have been monitored using the BetBuddy system. Since partnering with BetBuddy, OLG has twice received the World Lottery Associations' Best Overall Responsible Gambling Program award, most recently in 2018.

In qualitative research based on interviews with 150 OLG players, 9 out of 10 identified the BetBuddy play management tool as helpful in managing their personal gambling behaviours [5.3]. The tool is part of the OLG online gambling platform and it interacts with the players via targeted messaging and banners. John Wisternoff, OLG's Vice President of iGaming, said: "*It's very clear that we do not diagnose players, but we can respond to the activity that occurs on our website (…) The Bet Buddy engine in the background is analyzing play, and our marketing*

department has created a series of banners that talk about our tools, player protections and other items." The website delivers those banners (messages) based on the information provided by the BetBuddy algorithms [5.4].

In 2017, BetBuddy was acquired by Playtech – the world's largest provider of online gambling and sports betting software – for a total amount of €2.2 million [5.6]. In a move to affirm their continued commitment to responsible gambling, Playtech integrated BetBuddy into 9 platforms, including the Ontario Lottery and Gaming Operation (OLG) and BuzzBingo, and its solutions currently reach approximately 3 million registered gamblers [5.1].

Ian Ince, Head of Regulatory Affairs and Compliance at Playtech, explains [6]: *"BetBuddy is the leading company in this field and has a team that has focused exclusively on developing an industry-leading Responsible Gambling solution…This acquisition demonstrates our commitment to producing solutions and games that will enable Playtech to be the most responsive and responsible businesses in the industry."*

BetBuddy won RegTech supplier of the year at the Gambling Compliance Awards 2018 [5.5], in recognition of its contribution to industry regulation and compliance, and was shortlisted at the Lloyds Bank National Business Awards 2019 for the IA solutions, and a runner up to the winner Darktrace [5.1]

BetBuddy's technology effectively keeps Playtech at the forefront of the industry when it comes to promoting safer play. In 2020, Playtech's BetBuddy team was selected to lead the UK Gambling Commission collaboration group working on developing the first Industry Code for Product Design [5.7]. *"The use of BetBuddy technology and expertise, resulting from the fundamental research at City, gave BetBuddy and Playtech the trust required to lead this important regulatory industry initiative."* [5.1]

Contributing to parliamentary debate & setting industry standards
In a 2013 parliamentary debate of the Gambling Bill, MP Clive Efford read evidence from Dr Sally Gainsbury, Director of the National Problem Gambling Clinic, in which she cited BetBuddy as an example of technology which can assist in reducing problem gambling [5.8].
The Responsible Gambling Strategy Board has also cited BetBuddy in their progress report as an example of a product used to identify harmful play [5.9].

The Gambling Commission's Licencing Conditions and Codes of Practice require operators to identify "at risk customers". Operators are also now choosing to reveal responsible gambling Key Performance Indicators in their annual reports. In 2018 the former Sports Minister Tracey Crouch said the Government welcomed steps taken by some operators to incorporate behavioural analytics, into their responsible gambling systems, while at the 2018 Gambling Commission's Raising Standards Keynote Speech, Sarah Harrison, the UK's former regulator, commended the strategic importance of Playtech's acquisition of BetBuddy in meeting these obligations [5.10].

In a 2018 European Commission report evaluating exiting tools for enforcing online gambling rules and channelling demand towards controlled offers, Playtech's acquisition of BetBuddy serves as an example of regulators and industry being proactive and investing in technologies that enable the identification of players at risk. [5.11]

Raising awareness and helping industry comply with standards

City's research has attracted widespread media attention and members of the team regularly contribute to debate on the role of technology in RG.

In 2016, City and BetBuddy delivered a Responsible Gambling Algorithms Roundtable with 15 participants drawn from industry, treatment providers and regulators. The importance of explainable AI models for RG, such as the BetBuddy system, was widely acknowledged:

"*Interpretability can be an advantage when providing treatment as the counsellor has specific and relevant behavioural indicators to discuss.*" said Dirk Hansen, CEO Gamcare.

BetBuddy's CEO Dragecivic is also a board member of the Responsible Gambling Council, an independent non-profit organization that has led on the prevention of problem gambling around the world for over 35 years. Dragecivic has been invited to lead and contribute to several international events for raising standards in compliance with the current regulations.

Wider impact

City and BetBuddy have recently partnered with Kindred Plc to explore the use of AI to strengthen anti-money laundering decision-processes. They have produced an industry whitepaper of recommendations, as well as presenting early analytical research at the 2018 European Association for the Study of Gambling (EASG) conference. [5.12]

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

5.1 Playtech/BetBuddy testimonial from BetBuddy's CEO

5.2 Engineering and Physical Sciences Research Council (EPSRC). 2015. *Online gambling to get safer through better prediction of addiction.* Public release:
https://www.eurekalert.org/pub_releases/2015-10/eaps-ogt102315.php Accessed 08.12.2020.

5.3 BetBuddy, Case Study: *Ontario Lottery and Gaming Corporation and Using Big Data* (pdf) and Bigdata article *Using Big Data Analytics to Fight Gambling Addiction (2016)*
 https://bigdataanalyticsnews.com/using-big-data-analytics-to-fight-gambling-addiction/
Accessed 08.12.2020.

5.4 John Wisternoff, OLG's Vice President of iGaming, in Patricia McQueen, *PlayOLG Launches in Ontario. Responsible gambling and player protections are at the core of OLG's venture into online gaming.* Insights 2015 https://nasplmatrix.org/insights-files/pdf/2015MarchApril.pdf
Accessed 08.12.2020.

5.5. Playtech Annual Report 2018, available online at:
http://www.annualreports.com/HostedData/AnnualReports/PDF/LSE_PTEC_2018.pdf Accessed 08.12.2020.

5.6 Ian Ince in *Playtech acquires BetBuddy*, 2017, available at:
https://www.playtech.com/news/playtech-acquires-betbuddy Accessed 08.12.2020.

5.7 Daniel O'Boyle in Playtech, *GC chief McArthur defends track record, hails industry progress,* 2020 https://www.igamingbusiness.com/news/gc-chief-mcarthur-defends-track-record-hails-industry-progress Accessed 08.12.2020.

5.8 Gambling (Licencing and Advertising) Bill, Public Bill Committee, Tuesday 19 November 2013
https://publications.parliament.uk/pa/cm201314/cmpublic/gambling/131119/pm/131119s01.htm Accessed 08.12.2020.

5.9 RGSB report https://www.rgsb.org.uk/PDF/RGSB-Progress-Report-2017-18.pdf Accessed 08.12.2020.

5.10 Sarah Harrison, 2017. Raising Standards keynote speech
https://www.gamblingcommission.gov.uk/PDF/speeches/Raising-standards-keynote-speech-Sarah-Harrison-2017.pdf Accessed 08.12.2020.

5.11 European Commission report, 2018, *Evaluation of Regulatory Tools for Enforcing Online Gambling Rules and Channelling Demand towards Controlled Offers*
https://www.azarplus.com/wp-content/uploads/2019/02/Estudio-CE.pdf Accessed 08.12.2020.

5.12 Industry Stakeholder Interview Whitepaper, *Raising Standards in Compliance: Application of artificial intelligence to online gambling data to identify anomalous behaviours*, 2018
https://www.playtech.com/playtech-protect/media/3114/whitepaper-aml-and-ai-2jul2018.pdf Accessed 08.12.2020.

All sources are also available as pdf files.