SOCIETY OF ACTUARIES®

Innovation and Technology Research

Summary of Innovation and Technology Research Reports

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A Tour of AI Technologies in Time Series Prediction Report Summary

A Tour of AI Technologies in Time Series Prediction by Victoria Zhang, FSA, ACIA is an excellent primer on the topics of Artificial Intelligence (AI) and Machine Learning (ML). The author provides a summary of the respective definitions and subset relationships between AI, ML, DNN, and DL, as well as a projection of the potential financial impact among multiple business functions across 19 different industries. The advantages of AI to the actuarial community are many, but the author focuses on strong representability and better accuracy with a more detailed discussion of each one.

The focus of the report is two-fold. The first purpose is a detailed discussion of the potential actuarial applications for ML and DL models and examples of how they might work. The second is the demonstration of AI use for time series prediction and, again, review of the applicability of same. The models of focus for time series prediction are machine learning for classification, deep learning for prediction, and recurrent neural network for prediction and anomaly detection.

Chapter 1

The reader is introduced to six supervised learning-based algorithms. The Naive Bayes Classifier is based upon applying the Bayes Theorem with strong independent assumptions between different features. The K-Nearest Neighbor (KNN) is a non-parametric algorithm with no assumption of the underlying data distribution, instead built around the observation that similar things are near to each other. The Support Vector Machine (SVM) is based upon maximization of the decision boundary between distinct data classes. The Decision Tree algorithm is the systematic classification of a series of observations to build an optimal decision tree structure. The final two methods reviewed are Random Forest and Gradient Based Trees, which are both different variations of combining multiple decision trees.

The pros and cons of the various time series methods are discussed and contrasted for the reader with sample graphical representations plotted for each utilizing minute by minute NASDAQ 100 index values from late 2016 to early 2017.

Chapter 2

Two subsets of Deep Neural Networks (DNN) are compared with each other, Multi-Layer Perception (MLP) and Convolutional Neural Networks (CNN). In an MLP, every neuron in the current layer will have one corresponding connection to a neuron in the next layer. CNNs require fewer connections between neurons across layers and, thus, are more suitable for two-dimensional images. The study comparison leverages Bitcoin price data for seven years from 2012 through 2019.

Chapter 3

Time series is discussed using a specific subset of Recurrent Neural Networks (RNNs), the Long Short-Term Memory (LSTM) model. The goal in this chapter is the detection of anomalies in the time series data. Note that RNNs have internal memory and leverage observed information to predict the future.

Again, pros and cons of the LSTM versus an Autoregressive Integrated Moving Average (ARIMA) time series method are contrasted for the reader with sample graphical representations plotted for each utilizing minute by minute NASDAQ 100 index values from late 2016 to early 2017

Conclusion

The report summarizes the advantages and challenges of using AI technologies that specifically apply to the actuarial community. One objective of the report is to highlight opportunities for the application of AI to daily objectives. A second objective is to highlight real world examples of time series problem-solving. A brief review of AI challenges discussed, including privacy concerns, regulatory concerns, and the significant initial and ongoing investment costs. The author summarizes the opportunity for AI to benefit actuarial decision making while supporting the proven practice that no machine can replace human judgement and experience entirely.

The full research report can be found here: https://www.soa.org/resources/research-reports/2019/tour-ai-technologies/.

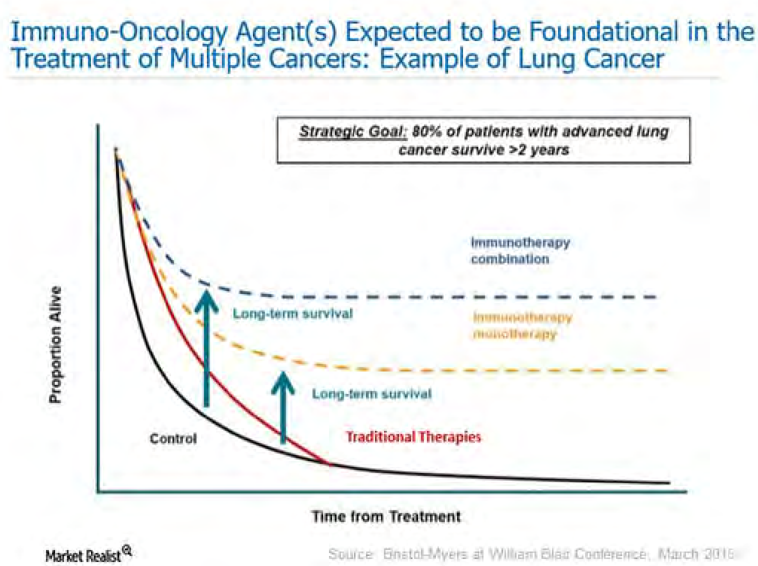
Cancer Genomics Report Summary

Since 2017, treatment of advanced deadly cancers – particularly lung cancer and metastatic melanoma – has undergone a major paradigm shift. Traditional pillars of cancer treatment – surgery, radiation, and chemotherapy – have moved to 2 new efficacious approaches: tumor genomics and immunotherapy.

The impact on the insurance industry is becoming increasingly profound. High morbidity and mortality are reduced significantly for roughly 30% of patients in these cancers, and increasingly other cancers, where 5-year survival rates have been below 50%.

Oncologists' new weapon is a class of antibody drugs led by Keytruda® (Merck) that free up the previously blocked immune system to recognize and destroy tumors. Collectively, these drugs are called Immuno-Oncology therapies, or I-O, sometimes called 'checkpoint inhibitors.' However, the release of the immune system can be overdone and cause side effects or worse. At least one tumor genetic test, TMB (tumor mutational burden), promises to pre-qualify patients for I-O, to lower this danger. TMB simply counts the number of mutations in biopsied tumor cells, without regard to the gene(s) or other fine detail. Counts over 15 generally qualify a patient for I-O treatment. For those with low numbers a second targeted genomic test, PD-L1, can still rescue and requalify treatment.

The chart below displays lung cancer, where FDA has now moved to approve chemotherapy-free treatments. There are 1.5 million lung cancer deaths annually – higher than prostate, colorectal, and breast cancers combined.



What is the forecasted cost-effectiveness of these drugs? Compared to prior standards of care, which could not increase survival, the combination of TMB and Keytruda appears to be cost-neutral for lung cancer, and cost-effective for metastatic melanoma. More clinical trials are needed to increase confidence of C-E assessments, but an anti-tumor 'memory' effect has been seen after 18 weeks of treatment in the majority of patients in one such study that may eventually limit the expenditures to roughly $70K cost (Keytruda price is ~$23K for 6 weeks).

SOA is eager to see more statistics over coming months on the cost comparison of I-O Therapy versus the current Standards of Care. However, the growing numbers of patients with decreased morbidity and mortality will bring significant outcry for coverage. Conversely, shorter treatment windows should limit outlays for insurers.

The full research report can be found here: https://www.soa.org/resources/research-reports/2019/cancer-genomics/.

Cloud Computing and Machine Learning Uses in the Actuarial Profession

Insurance companies are operating in a fast and ongoing technological and consumer transformation environment. Over the past decades, there have been tremendous advancements in technology and one of them is cloud computing.

How the insurance industry and actuarial profession are impacted by the cloud

Insurtechs are gaining popularity with increasing investment from insurers to explore innovative ways on how insurance companies interact with their customers. For example, a need for more advanced analytical capabilities for dynamic pricing is required to provide immediate and individualized quotes for insurance products for Millennials and Gen Z, who prefer digital / Omni channel and 24/7 customer service availability. The agility and capacity offered by the cloud has enabled new forms of insurance to be introduced.

The use of cloud services by actuaries is not uncommon, and most cloud users expect cloud service to have a positive impact to their work. The most common use for actuaries is leveraging the cloud for faster computation (i.e. distributed computing).

Impact on the actuarial profession

Thanks to the widespread, personal health tracking apps, and other data-intensive technologies, an enormous amount of data are now available for insurers to do more analysis. Modeling actuaries are beginning to take on data science techniques, such as predictive analytics, and combine them along with their specialized training in insurance, statistics, and economics.

The use of the cloud in financial modeling and actuarial processes

We have witnessed increasingly sophisticated actuarial financial reporting requirements around the world, such as Actuarial Guideline 43 and C-3 Phase II, Solvency II, and IFRS 17, which usually involves more complex modelling. The cloud provides actuaries with a new solution to data storage, run-time reduction, process streamlining, etc., to cope with ever-changing regulatory requirements.

The cloud changes the way in which data is collected with its massive capacity, connectivity, and ability to effectively leverage collected data. The cloud has practically no limit on storage, as it can expand on demand, with additional capacity at-the-ready. The cloud is also packed with application programming interfaces to ease connectivity to data of heterogeneous formats from multiple third-party vendors and public records, making it easier to enrich internal information with external data. Cloud providers continuously improve and push out new analytics capabilities, which insurers can utilize for their own analyses.

The cloud is able to efficiently distribute nested stochastics or deterministic-on-stochastic runs, which translates into a tremendous advantage in reducing runtime. Sometimes, actuaries need to simplify their model to be efficient. This precept is particularly true for nested stochastic or deterministic-on-stochastic models. Using the cloud avoids over-simplification of the model, yet still maintains a reasonable runtime.

Using the cloud allows automation of the reporting pipeline. This is possible via migrating the model that produces the reporting of financial results to the cloud. Adjusted model output can be fed straight into visualizations and reporting frameworks using robust industry business analytic tools. Any authorized user can replace existing static report templates that are currently prepared using Microsoft Office tools with dynamic web-based dashboards accessible at any time.

Considerations when using the cloud

There are two governance considerations for insurers: data governance and model governance. Insurers need to update their data and model governance framework, taking into account the use of the cloud. Using a cloud provider requires a lot of trust in their security protocols and may pose unexpected privacy concerns. A dedicated cloud model governance committee that spans the whole company would be ideal. Also, the model governance standards related to operating models in the cloud should be relatively consistent with and complementary to the model governance standards.

When thinking about the type of cloud structure to adopt, actuaries must be careful about the exact purpose and needs the cloud is meant to satisfy. Key considerations are budget; security and compliance requirements; hardware and virtual server control; failover control; service-level agreements; cloud resource utilization and consistency; what data will be used in the cloud environment; internal IT resources to support the services; how many teams or groups will be utilizing the cloud and how similar the processes are; and how much automation can be achieved if a private cloud is utilized.

Use of artificial intelligence and machine learning by actuaries

Artificial intelligence (AI) can be defined as any attempt to make machines learn from experience and to perform human tasks, whereas machine learning is a subfield of AI that allows machines, programs, or algorithms to learn and improve from data. Currently, AI and machine learning are becoming increasingly important thanks to big data, ever-improving algorithms, and the greater capacities of storage and computing.

The most common uses of machine learning in actuarial science include pricing, claims, in-force management, risk, underwriting, valuation, and disease management. In this research report, four case studies were presented, providing insight into how actuaries employ machine learning in their daily work. Machine learning algorithms are efficient in analyzing large and granular datasets. It is believed that will AI will play an increasingly important role in the process of decision-making going forward.

Common machine learning algorithms and tools

In machine learning, there are two kinds of tasks, supervised learning and unsupervised learning. The goal of supervised learning is to determine the model that best fits the data so as to predict an output given a new set of input. Unsupervised learning, however, is used to draw inferences that are not explicit using the characteristics of data. Examples of supervised learning include classification and regression tree (CART) and random forest, which are commonly used in pricing analysis, creating reserving algorithms, and evaluating risks with complex interactions. A common unsupervised learning algorithm is the k-means algorithm, which is frequently used in marketing campaigns to identify similar exposures for claims management and process optimization. R and Python are ordinary programming languages used to perform machine learning analysis. Different packages in R and Python allow a community to easily implement machine learning.

Considerations for model selection and results interpretations

There are plenty of algorithms available and, when selecting the model, we have to carefully tradeoff between complexity and interpretability. When implementing a new machine learning algorithm, it is crucial to understand the theory behind it in order to understand how it works, in what instances it is appropriate, and what range of parameters is appropriate for a given situation. It is as important to analyze results closely to understand what is hidden behind models.

Overall, cloud technology has the potential to impact many practice areas of actuaries, including, but not limited to, pricing; valuation and reserving; enterprise risk management; and experience analyses and assumptions. In order to benefit from the opportunities presented by cloud computing and granular analyses, actuaries will need to either become data and technology experts or become familiar enough with these topics to effectively provide the required solutions and skill sets to employers.

The full research report can be found here:
https://www.soa.org/globalassets/assets/files/resources/research-report/2019/cloud-computing.pdf.

Behavior Science Report Summary

The Behavioral Science Report is designed to provide general familiarity in the subject of Behavioral Economics (BE) and motivate readers to consider additional research on the topic. The research report was completed by RRC in June of 2019. RRC is an insurance consulting firm serving the regulatory community and has performed a range of research projects for the SOA.

BE is a method of economic analysis that applies psychological insights into human behavior to explain and nudge economic decision-making. The field of BE blends insights of psychology and economics, and provides some valuable insights that individuals are not behaving in their own best interests. BE provides a framework to understand when and how people make errors. Systematic errors or biases recur predictably in particular circumstances.

The brain is best thought of as an organization of systems that interact with each other. A crucial insight is that the brain is a democracy. That is, there is no leading decision-maker. Although the behavioral goal of an individual can be stated as maximizing happiness, attaining that goal requires contributions from several brain regions. BE attempts to integrate psychologists' understanding of human behavior into economic analysis.

Lessons from BE can be used to create environments that nudge people toward wiser decisions and healthier lives. There are many benefits of BE for insurance, including better educating applicants on the benefits of truthful and correct disclosure, which can improve the underwriting process and result. This, in turn, results in more reliable applications being submitted, which leads to a reduction in the time to obtain underwriting approval. An added benefit is the opportunity to provide more life insurance to more consumers by improving the buying process and making the process more personalized and relevant.

There are potential drawbacks to BE and some elements to consider include a negative impact on client experience (if done poorly) and the resource-intensive nature of BE. While customer experience is critical, there is the balance of needing to mitigate mortality and morbidity risk with improvements to the client experience.

The report reviews several BE techniques that could be applied to guide product design, modeling, and underwriting. The focus of this research is on life insurance underwriting, and much of the research being done is to test how BE can be utilized to improve applicant disclosures. Current insurance applications encourage fast thinking, resulting in people providing less accurate information in applications for insurance.

The research reviewed existing literature regarding industry approaches and primarily summarized industry perspectives from interviews conducted with 13 panelists using a questionnaire developed by RRC. Panelists included members from insurance, reinsurance, and consulting.

BE techniques considered in the report include Framing, Nudges, Cognitive aids, Social Norming, Availability heuristics, Anchoring, Messenger effect, Managing inertia, Fluency, Choice Architecture, Sentinel Effect, Scaling, Hovering Effect, Psychological Manipulation, and Prospect Theory. These BE techniques are evaluated against a series of improvements that can be made to the Underwriting process. Regulatory considerations are also briefly discussed as Regulatory requirements are often a concern around underwriting application changes. The techniques are also evaluated for their ability to improve marketing and distribution of products, to improve advisor behavior, and deliver post-sale customer engagement.

In summary, the report provides an overview of how BE can be applied to introductory changes in the existing paradigm of Insurance customer journeys. Readers are also provided with additional resources to consider to further their understanding of BE.

The full research report can be found here: https://www.soa.org/globalassets/assets/files/resources/research-report/2019/behavioral-science-report.pdf.

Emerging Data Analytics Techniques with Actuarial Applications Report Summary

Summary Part I – Background

Data Analytics relies on two key elements - data and techniques used - to extract meaningful information from the data. **Data volume** worldwide is growing at a rate of approximately 50% per year. The Cloud offers storage solutions for the massive volume of data. However, data may come from various sources, including transaction portals, smart meter/GPS, social media, etc. This leads to challenges when data types and structures are different. Common steps to set up a data analytics framework are to assess the data quality, obtain insights through visualization, select and implement a model, assess the model utility, and predict and make decisions. With respect to the machine learning techniques used to analyze data and, ultimately, make predictions, there are mainly two classes, supervised and unsupervised.

Supervised learning aims to predict the response variable from the input variables. It prioritizes prediction rather than inference, which is the main difference compared to statistical modeling.

> #1. Regression and Generalized Linear Models (GLMS) techniques: a multiple linear regression model is generalized to predict variables that have non-normal distributions.
>
> #2. Tree-based Methods: iteratively partition the prediction space into two regions based on the splitting rule (consists of a predictor variable and a cut-point) at each step, where the rule is determined so that the residual sum of squares for the observations in the two regions is minimized. Simple decision trees are easy to display and interpret but are prone to overfitting with high variance. Bagging and Random Forests are modifications of this approach and improve prediction while reducing variance.
>
> #3. Neutral Networks: NNs are composed of an input layer, hidden layer(s), and an output layer. One form of NN is feed-forward where the computations pass from input through the hidden layers to the output layer. Recurrent NN is another form, which involves loops between the hidden layers. Backpropagation is used to improve accuracy.
>
> #4. Predictive Modeling: techniques where the emphasis is on predicting the risk factor. They are at the forefront of regression techniques and machine-learning techniques.

Unsupervised learning is used to find a hidden structure or pattern within unlabeled data.

> #1. Principal Component Analysis: PCA is used to reduce the dimensions of a dataset while maintaining as much information related to variation as possible
>
> #2. Cluster Analysis: a process of grouping objects from a dataset into clusters with similar characteristics. Partitional clustering segments observations into a pre-defined number of clusters. K-means and the Hierarchical method are alternative clustering algorithms.

#3. Genetic Algorithms: GA is a type of optimization algorithm, which breeds various solutions to a problem with guiding rules in order to determine a best solution.

#4. Neutral Network: in the form of unsupervised learning, there is no response variable given in the dataset, so the NN serves to simply group data according to patterns.

Other data analytics techniques to be added

#1. Markov Chain Monte Carlo Simulation: MCMC can be used to solve cumbersome integrals.

#2. Bayesian Analysis: prior distribution of an unknown parameter is updated with the information from the data

Summary Part II – A review of articles that focus on applications of emerging technologies

Mortality rate forecasting (life) – Deprez, et al. (2017) used regression trees; Kopinsky (2017) used tree models; Hainaut (2018) used NN analyser; Shang (2017) used K-nearest, regression, tree, and NN.

Health care claims modeling – Toyota and Niki (2015) used visualization system; Kareem (2017) used supervised and unsupervised techniques; Diana (2019) used GLM, tree, and Bayesian analysis; Hartman (2018) used boosting and logistic regression.

Reserves (life/non-life) – Harej (2017) used artificial NN; Llaguno (2017) used clustering algorithm; Adesina (2018) used GLM; Gabrielli (2018) used regression and NN; Spedicato (2018) used GLM and boosted trees.

Claims modeling (non-life) – Frees (2016) used copula regression; Mendes (2017); Kunce and Chatterjee (2017) used clustering; Gross and Evans (2019); Aminzadeh and Deng (2019) used Bayesian; Zhang and Miljkovic (2019) used GLM and Bayesian Analysis; Noll (2018) used GLM, trees, and NN; Ferroario (2018) used NN; Schelldorfer and Wuthrich (2019) used NN; Weidner (2016); Gao (2018); Gao and Wuthrich (2018) used convolutional NN.

Fraud (life/non-life) – Chalk and McMurtrie (2016); Xia (2018); Guo (2003); Purushotham (2016); Wuthrich (2016); Yao (2008)

Actuarial packages: in R – ChainLadder, Actuar, Lifecontingencies, Forecast, Demography, Life Metrics, StMoMo, and ILC; in Python – Pandas, Numpy, SciPy, Matplotlib, Bokeh, Seaborn, PyMC3, Lifelines, scikit-learn, and Pyliferisk.

Summary Part III – Three actuarial case studies

#1. Chainladder in R: the aim is to show the basic functionality of the ChainLadder package in R to determine IBNR reserves for non-life insurers. The steps are (1) import and organize data, (2) calculate age-to-age development factors, and (3) calculate reserve estimates.

#2. Claims frequency in motor insurance: the aim is to model the number of claims on a given policy in R. The steps are (1) descriptive statistics, (2) model and variable selections, (3) estimate of parameters using GLM, (4) assess utility, and (5) alternative model – regression tree.

#3. Mortality: the aim is to model and forecast human mortality. The steps are (1) descriptive statistics (and visualization), (2) generalized age-period-cohort model and parameters estimates, (3) residual analysis, and (4) prediction.

The full research report can be found here:
https://www.soa.org/globalassets/assets/files/resources/research-report/2019/emerging-analytics-techniques-applications.pdf.

Insurance Regulatory Issues in the United States Report Summary

The current regulatory environment in the United States for using predictive analytics and big data across actuarial practice areas, both at the state and federal levels, continues to emerge. How these techniques and these types of datasets impact the risk selection, risk categorization, and ratemaking processes continues to evolve. To help put perspective on the current status and emerging risks and opportunities, Risk & Regulatory Consulting performed research and conducted interviews that are summarized within their report, not only to give insights to current companies using these techniques, but also to assist actuaries who are looking to invest time and resources in their future development and use.

Key takeaways from the report include a focus on interview responses from regulators. Regulators are tasked with ensuring that the rates for the insurance products are adequate and not unfairly discriminatory, among other responsibilities. Since the advanced modeling techniques could vary across companies, regulators are looking to companies to appropriately demonstrate that their use of big data and predictive analytics in determining rates is appropriate for the products and not unreasonably biased. Some companies that are exploring advanced analytics are using them in ratemaking, while others are limiting their reliance on big data and advanced analytics until comprehensive regulatory guidance becomes available.

The report also discusses modeling techniques that are used for ratemaking. Basic tools such as trending and linear regression are still in use, and models that are more complex are increasingly being used. One of the most common complex tools used is Generalized Linear Models (GLM), but Machine Learning techniques are also increasingly being considered and used. Generalized Linear Models are easier to explain to regulators and stakeholders than Machine Learning, whereas the results from Machine Learning are likely to be more accurate. Companies need to assess the risk and reward tradeoff between the tools that they consider or use.

Finally, the paper discusses current and emerging issues, recommended best practices, and implications of implementation of big data and advanced predictive analytics based on the research that was completed. The risks to the insurer and policyholders, as well as the impacts of the use of advanced analytics in ratemaking, are also addressed. As the use of predictive analytics evolves, the research and questionnaire responses show that models and methods used to determine rates must be defendable and explainable, and the companies must be able to demonstrate that the rates determined are not arbitrarily discriminatory.

To see the full report, look for it on the SOA website at https://www.soa.org/resources/research-reports/2019/insurance-regulatory-issues-us/.

Technology in Microinsurance Report Summary

Microinsurance refers to a set of strategies that makes appropriate insurance coverage available to low-income people. In overcoming the various challenges faced by this target market, a growing number of innovations and technologies have emerged in the arena of microinsurance. This literature review provides insights on emerging technologies that interact with the actuarial profession within the space of microinsurance for the purpose of establishing a frame of reference for actuaries to use in their work. Furthermore, it intends to spark readers' interest in, and create a vision for, how microinsurance and its associated technologies may impact the actuarial industry in the future.

This report assembles publicly-available literature from desktop studies and key-person interviews. Each piece of literature is categorized under one of the following four sections: rating, distribution, claims adjudication, and payment facilitation. These sections are then subcategorized by type of technology. The literature in each section highlights how technology impacts the given aspect of the insurance process. Discussion begins with an overview of the technology, a description of how the technology impacts the specific aspect of the microinsurance process, and possible implications and applications for actuaries as a result of the technology.

Highlights of Technology in Microinsurance

Rating: Technology is helping to address both the lack of good quality data and the lack of technical expertise in the microinsurance space in order to improve the rating processes. Remote-sensing data can be employed to develop the index used in index-based insurance under certain circumstances. Various innovative ways to gather big data on the target demographic have been explored. Pricing tools can also help local insurers in developing countries.

Distribution: Innovative distribution channels addressing constraints unique to low-income people include the mobile network operators and the agent-led insurance platforms. Technologies applied in mobile health, digital marketing, artificial intelligence, and chat bots can also promote the distribution of microinsurance.

Claims adjudication: Fast claim processing allows insurers to reduce expenses and fraud, as well as instill trust in customers. Technologies that address these issues include claims administrative systems, smartphone applications, remote-sensing, Internet of Things (IoT), blockchain, and machine learning.

Payment facilitation: Mobile money and mobile airtime have been used as substitutes for banks to enable quick, convenient, and relatively low-cost payments of premiums and claims. New, transformative technologies like blockchain and other online platforms are also emerging within the space of microinsurance.

Applications for Actuaries

As new products and environments continue to emerge, actuaries must continue to evolve in their ability to serve all aspects of the insurance market. This report recommends that actuaries can contribute to the following areas: data analytics, data collection, and setting up of back-office systems; implementation of new technologies; capacity building in technical skills; regulatory; and risk management.

The full report can be found here: https://www.soa.org/globalassets/assets/files/resources/research-report/2019/2019-technology-microinsurance.pdf.

Big Data and the Future Actuary Report Summary

Access to big, non-traditional data has, is, and will affect every industry in the market, as well as usher in a few new ones. In insurance, access to big data means the relationship between insurers and their customers is increasingly complex and intimate. On the positive side, this encourages insurers to innovate and find ways to deliver value across the customer lifecycle. However, it also invites questions of privacy, transparency, and what constitutes taking data access 'too far.'

Using Non-Traditional Data in Traditional Ways

There's no shortage of ways that big data influences and encourages innovation in the more traditional insurance processes. New niche products can target small segments of the population for a fraction of the cost. AI can simplify and improve accuracy in underwriting. Drone footage can determine which properties are more at risk in a natural disaster zone. The possibilities across the broader industry are seemingly limitless.

Many forms of data that are not necessarily new to the insurance industry are changing. Whether that refers to the data's complexity, accessibility, or the way it's collected and analyzed completely depends on the data and the person/company collecting it. Data that will experience this kind of shift includes **demographic**, **financial**, **government**, **climate**, **medical**, **motor vehicle records**, **public records**, and **telematics**.

The industry will also have access to some relatively new kinds of data, particularly epigenetics data and digital behavioral data. **Epigenetics data** refers to information pertaining to 'cellular age.' This can predict how long one is likely to live, whether or not they're likely to avoid common diseases, etc. **Digital behavioral data** is possibly the most valuable source of big data to insurance and comes in the form of wearables, apps, and online platforms that constantly track behavior, habits, location, and health. This data can be used in everything from risk pricing, fraud prevention, underwriting products, and more.

With access to big data comes great responsibility. Insurers should be especially wary of predictive algorithms that have the potential to inherit societal discriminatory prejudices through machine learning. While significant advancements have been made, there is no agreed upon way to ensure AI and machine learning operate free of any bias. It is illegal for insurers to discriminate on the basis of race, religion, or national origin in the underwriting, pricing, and claims processes, making integrating these new technologies tricky.

On the more positive side of this equation, access to these big data sources provides endless opportunities for insurers to meaningfully engage their customers. Companies placing the customer at the center of business decisions regularly outperform those that don't, and the insurance industry has the tools to enable this. Insurers that recognize this potential and act on it can provide continuous value, helping customers live healthier, happier, and wealthier lives.

Using Non-Traditional Data in Non-Traditional Ways

Outside of using non-traditional data to improve and innovate long-standing industry practices and processes, there are plenty of new ways for actuaries and insurers to push traditional boundaries. At the center of this is the idea that the insurance industry is moving away from a 'detect and repair' industry towards a more proactive 'predict and prevent.' Here are a few ways in which the insurance industry is actively working towards this shift:

1. **Risk Management and Wellness Programs:** Perhaps the most intuitive way insurers can drive value for customers is risk management and wellness programs, which provide insights and incentives to help consumers improve their mental and physical well-being.
2. **Patient Management Programs for the Chronically Ill:** Partnerships between healthcare providers and insurers can develop patient management programs for customers suffering from chronic diseases.
3. **Value-Based Payment Models:** These next-generation payment contracts can directly link individual behavior with the management of chronic diseases, providing incentives for customers to improve their lives through lifestyle insights and suggestions.
4. **Pay-as-you-live and usage-based insurance:** These pricing solutions will benefit consumers through seamlessly interconnected insurance products, delivering continuous value through insights on health, wealth, and safety.
5. **Internet of things integration**
6. **Covering new risks**

Becoming an Actuary of the Future

Access to non-traditional, big data does more than shift the insurance industry, it changes what it means to be an actuary. The actuary of the future will be part mathematician, part data scientist, part digital strategist, part computer programmer, and part design thinker, integrating all these skills to make the most of new technologies and partnerships alike. New data sources will provide a wealth of both structured and unstructured data that will allow actuaries with the right programming skills to develop algorithms capable of efficiently working with massive datasets.

More than anything, the actuaries of tomorrow will see their role shift towards the customer in ways it never has before. As the insurance industry becomes simultaneously more customer centric and proactive, products, programs, and services will reflect a more engaged customer base, ready to be engaged throughout the duration of their policies through meaningful, value-driven initiatives. Actuaries will be at the center of this shift.

The full research report can be found here: https://www.soa.org/resources/research-reports/2019/big-data-future-actuary/.

Top Actuarial Technologies of 2019 Report Summary

This research study aims to understand the current and planned use of various technology types and tools and to highlight those technologies that are anticipated to grow the fastest among actuaries in 2019. It also explores the growing set of emerging technologies and discusses perspectives on the abilities of actuaries to adopt them. In order to gather information and insight regarding technologies used and anticipated to be used in actuarial practice, the researchers conducted 17 qualitative expert interviews and a quantitative survey of 140 actuaries.

Key Findings

- The types of technology that actuaries expect to increase the most in usage in the coming year include data visualization, predictive modeling, cloud computing and storage, and collaborative tools.
- Data visualization is not only the fastest growing technology among actuaries, it is also used by more actuaries than other technologies in the survey.
- The predictive modeling tools, R and Python, are currently used by more actuaries than any other tools in our survey. They are also among the fastest growing in their use among actuaries.
- Across the top technologies, more of the anticipated increase in use is expected to come from actuaries currently using these tools than from those who plan to start using them.
- While there are many factors driving the increased use of these technologies, a common theme is how they can bring efficiencies to actuarial work.
- There are also many emerging technologies that actuaries expect to leverage in their work beyond 2019. Some that hold promise include robotic process automation, serverless architecture, and expanded open source applications and libraries.
- Experts interviewed as part of this project exhibited confidence that actuaries are capable of learning and implementing new technologies if they are given appropriate priority.

The full report can be found here: https://www.soa.org/globalassets/assets/files/resources/research-report/2019/actuarial-innovation-technology.pdf.

Ethics in AI Report Summary

This paper, written by Neil Raden, an established author, researcher, and analyst, highlights the ethical risks arising from the application of Artificial Intelligence (AI) in actuarial practice, the clear potential for doing harm with AI, and how to avoid it. Broad in scope, the paper also provides advice on the organization of the actuarial department for AI in terms of skill, team, and diversity.

Why it is Relevant Today

AI is an essential aspect of Digital Transformation. The insurance industry is subject to pressures of digital transformation, promising increased efficiency, new products and services, and new markets. Digital transformation comes with increased risk, especially from AI. Moving from manual methods to unattended decision-making systems creates risk from bias, privacy intrusions, security, and issues of fairness.

The role of actuaries will change, and new guidelines for ethical practice are needed. Actuarial societies have provided ethical guidance to the practice. This paper describes the different or additional guidance that is needed.

AI, the Social Context and Ethics

The research focuses on "available" AI, (often referred to as Narrow AI) primarily Machine Learning (ML), deep learning, predictive analytics, and other approaches that are already in use, not Artificial General Intelligence/Cognitive Systems, the proposed thinking AI. Available AI includes algorithms and experiments actuaries may specify or develop, as well as embedded AI in software packages and tools available from commercial vendors, cloud providers, and open sources.

Formulating and practicing the ethical application of AI in actuarial work requires consideration of some simple guidelines that can be useful for formulating a more detailed policy, such as:

- AI researchers should acknowledge their work can be used maliciously
- Policymakers need to learn from technical experts about these threats
- The AI world must learn from cybersecurity experts on how to protect its systems
- Ethical frameworks for AI need to be developed and followed
- More people need to be involved in these discussions - not just AI scientists and policymakers, but also businesses, and the general public.

Ethics in AI is an issue when the social context is involved. Social context refers to the immediate physical and social setting in which people live or in which something happens or develops. It includes the culture that the individual was educated or lived in and the people and institutions with whom they interact. Almost everything an actuary does involves a social context – people. When there is a social context in AI, there are ethical questions.

Ethical Risk in General: Data, Bias and DIY (Do It Yourself)

AI ethics is a much broader discussion than the origins, effects, and biases in AI, and the potentially disastrous results of unmethodical experiments. Actual use and deployment in actuarial departments have the potential for ethical dilemmas. In general, ethics refers to standards of morally good or bad, right or wrong conduct. Defining and detecting unethical behavior or processes with AI includes:

- Discrimination
- Diversity and Inclusion
- Gender Equity
- Artificial Intelligence and Autonomous Systems
- Biotechnology
- Privacy
- Sustainability
- Governance
- Conflicts of Interest
- Insensitivity
- Inequality

Other risks exist when utilizing the expanding market of data brokers and providers, many unregulated and of unknown quality of data that may cross the line of ethical practice by providing detailed information on individuals not available previously, such as: Personal Demographics/Sociographics, Electronic Health Records (EHR), Credit, Psychographic profiling and Digital Phenotyping

Bias is possibly the most obvious ethical risk within a model. Bias enters models through the selection of data and by the background of the developers. AI systems developed just a few years ago contained many prejudicial biases, which are unacceptable today (e.g. gender and race bias). It could be countered with the use of broader and more diverse groups in development and testing. Machine Learning depends on extensive collections of data, effectively becoming the codification of history. Within these histories, there are prejudices, biases, and societal injustices that have existed for years.

Other ethical risks include:

- Personally Identifiable Information - AI engineers are careful to anonymize data sources, but bad actors are adept at defeating that by including other data sources that can still identify an individual.
- Reliance on repeatable algorithms without human oversight.
- Amateurish development.

Five Pillars of Ethical AI

The paper proposes a five-point guideline for addressing ethics in AI, the "Five Pillars of Ethical AI":

Responsibility: for what you develop and what you use
Transparency: Logic of an AI must be viewable
Predictability: perhaps not its workings but surely its effect
Auditability: like a new drug is monitored for adverse effects
Incorruptibility: An AI in place must absolutely be incorruptible

The full report will be published on the SOA website in the near future.

About The Society of Actuaries

The Society of Actuaries (SOA), formed in 1949, is one of the largest actuarial professional organizations in the world dedicated to serving more than 32,000 actuarial members and the public in the United States, Canada and worldwide. In line with the SOA Vision Statement, actuaries act as business leaders who develop and use mathematical models to measure and manage risk in support of financial security for individuals, organizations and the public.

The SOA supports actuaries and advances knowledge through research and education. As part of its work, the SOA seeks to inform public policy development and public understanding through research. The SOA aspires to be a trusted source of objective, data-driven research and analysis with an actuarial perspective for its members, industry, policymakers and the public. This distinct perspective comes from the SOA as an association of actuaries, who have a rigorous formal education and direct experience as practitioners as they perform applied research. The SOA also welcomes the opportunity to partner with other organizations in our work where appropriate.

The SOA has a history of working with public policymakers and regulators in developing historical experience studies and projection techniques as well as individual reports on health care, retirement and other topics. The SOA's research is intended to aid the work of policymakers and regulators and follow certain core principles:

Objectivity: The SOA's research informs and provides analysis that can be relied upon by other individuals or organizations involved in public policy discussions. The SOA does not take advocacy positions or lobby specific policy proposals.

Quality: The SOA aspires to the highest ethical and quality standards in all of its research and analysis. Our research process is overseen by experienced actuaries and nonactuaries from a range of industry sectors and organizations. A rigorous peer-review process ensures the quality and integrity of our work.

Relevance: The SOA provides timely research on public policy issues. Our research advances actuarial knowledge while providing critical insights on key policy issues, and thereby provides value to stakeholders and decision makers.

Quantification: The SOA leverages the diverse skill sets of actuaries to provide research and findings that are driven by the best available data and methods. Actuaries use detailed modeling to analyze financial risk and provide distinct insight and quantification. Further, actuarial standards require transparency and the disclosure of the assumptions and analytic approach underlying the work.

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