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The Diabetic Patient Agent

Modeling Disease in Humans and the Healthcare System Response

Springer

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Foreword

Diabetes has many shades of gray. Healthcare providers are often reductionist, attempting to simplify the process to make them understandable. A person with a fasting glucose of 7.0 mmol/L has diabetes and one with 6.9 mmol/L has prediabetes. Yet these two individuals are the medical shades of gray, one now treated for a chronic condition and the other only considered high risk. Medicine has likewise developed disease models to predict outcomes and stratify risk factors. The effort has focused on a few variables with the greatest level of influence for long-term outcomes. The UK Prospective Diabetes Study Risk Engine (http://www.dtu.ox.ac.uk/riskengine/) has 10 variables in the well-tested model to predict 10-year risk. There are multiple lessor factors that influence outcomes; however, the model becomes complex and the identification of the lesser risk factors does not significantly predict on term outcome. The models do not address the day-to-day management of diabetes that eventually determines long term outcome and cost. As with other complex modeling in ecology, economics, and marketing, computer modeling has the potential of changing our understanding of complex disease processes and the human interaction with the environment.

Paranjape and his coauthors have brought to the reader a unique prospective in disease modeling that embraces complexity and addresses variability that is seen in the human body in everyday life. Historically, the model evolves from the expectation that computers have “artificial intelligences”. No longer do we discuss whether computers demonstrate intelligence, but only how to best use the intelligence to address complex questions. We reflect on existing models of ecological systems, advanced marketing used by Internet marketing and discuss the “butterfly effect” as we watch the weather.

In reading about patient agents and interaction tracked over time, we recognize the potential building blocks that influence physiological factors of blood glucose control and human behavior as it relates to diabetes. The agent model is built multi-dimensionally; viewing glucose control, diet, exercise, physician–patient interaction, diabetes self-awareness and interaction with the health system.The complexity that is often avoided from the clinicians prospective is embraced by the software engineers. The beauty of the work is the message that it is time to move beyond the data-driven models developed by the Center of Disease Control and the academic medical centers and look toward computer science to develop models that provide substantially more information for both individual patients and populations reporting.

One only expects that over time, the model grows both with the introduction of more interactions and testing against real patients. As providers, we asked ourselves how to best use blood glucose monitoring to effectively manage patients without breaking the bank. The common approach is to clinically test options and measure outcomes or turn toward expected opinion or personal experience. It is not that the science of medicine has abandoned us, but that the answers to relatively simple questions are too expensive to effectively resolve. The follow-on question is whether a patient changes treatment or behavior based on the blood glucose results. The complex agent model addresses both these issues providing information that balances the frequency of testing with outcomes. It also introduces the potential of identifying an abnormal reading that may cascade to either hyper or hypoglycemia over time as an early alert system allowing for early intervention.

One only expects that over time, the model grows both with the introduction of more interactions and testing against real patients. The agent model obviously assists patients, providers, and the healthcare system. The applications are endless and exciting. We look forward to what the future will bring.

Honolulu, USA Joseph Humphry, MD

Joseph Humphry, MD Program Medical Director and a medical provider with a focus on chronic disease at **Lānaʻi Community Health Center (LCHC)**. In April 2013, he accepted the additional role of the **LCHC** Medical Director. He is a primary internist with special interest in diabetes who has spent the majority of his clinical career working with minority and underprivileged patients including Native Hawaiians and Pacific Islanders. He has worked within the FQHC healthcare system for over 25 years. He is a graduate of the University of California at San Francisco School of Medicine and completed his internship at San Joaquin Medical Center in Stockton California and completed internal medicine residency at the University of Rochester and UCLA. He retired in December 2011 as part-time Medical Director for the last 22 years with HMSA. His interest in computers and medicine dates back to the late 80s when he programmed a diabetes registry program for the Hawaii State Diabetes Control Program. In 2000, he developed Ohana Health Project for monitoring diabetes. In 2005, he joined the Joslin Diabetes Center team developing the Chronic Disease Management Program (CDMP).

Preface

This volume is the final result of over 10 years of research work in the area of modeling Diabetes and the Healthcare Systems. The work has been carried out by a number of excellent graduate students in the Electronic Systems Engineering program at the University of Regina under my supervision. The idea of modeling a human patient with diabetes was the natural extension of other work done in the research group on modeling complex interacting systems. The first work in this area was performed with Ms. Sara Ghoreishi Nejad who first started the work of developing a software system to model the evolution of blood sugar in a human diabetic patient. This work was extended by Mr. Robert Martens. These ideas were taken much further in Mr. Simerjit Singh's thesis work in which he developed a capability to include the interaction of the patient with the healthcare system. The final thesis in this area was done by Dr. Zhanle Wang in his MASc thesis work in which he extended the model to include the full 24-h circadian cycle and introduced the ideas of the patient agent being self-aware and adjusting its behavior based on observing that its blood sugars were becoming high and therefore increase exercise and decrease food intake.

This manuscript is essentially the MASc thesis of Mr. Simerjit Gill and of Dr. Zhanle Wang put together with some additional thoughts included in the introductory and concluding chapters. We sincerely hope that these highly complementary works presented together will have an impact on the healthcare decisions that are made with regards to this major illness and that this work will stimulate further collaborations in modeling and simulation in this important field.

Regina, Canada

Raman Paranjape
Zhanle (Gerald) Wang
Simerjit Gill

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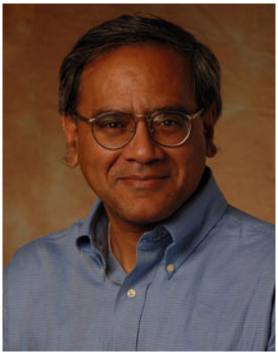

Raman Paranjape (Ph.D., P.Eng) is a Professor in the Electronic Systems Engineering Program at the University of Regina. He completed the Ph.D. degree in Electrical Engineering from the University of Alberta in 1989. He worked as a Post-Doc fellow at the University of Calgary and then as a Research Scientist at Array Systems Computing Inc. (Toronto) prior to joining the University of Regina in 1997.

Dr. Paranjape's research interests are in both physical systems and software systems. He has a strong research program in mobile and software agent systems in simulation and modeling. He has done seminal research work in modeling of healthcare systems using software agents for applications in mammography analysis and retrieval, surgical wait-times, and modeling of diabetes. In addition, his group developed new control strategies for demand response with applications in power systems and the smart grid. Research in physical systems has focused on the development of sensor systems and new technologies in image and signal processing for real world applications in robotics and automatation. He is a co-developer of the TransitLive Configuration (TLC) a vehicle tracking system in use in the City of Regina and the Regina Pipe Crawler (RPC) a robotic inspection system. He has published 55 reviewed journal articles and book chapters, 85 conference papers and has numerous grants and research projects.

Zhanle (Gerald) Wang (Ph.D., P.Eng) is currently a Lecturer in Electronic Systems Engineering, Faculty of Engineering and Applied Science at University of Regina, Canada. He received both his M.A.Sc. and Ph.D. in Electronic Systems Engineering from the University of Regina, Canada, in 2012 and 2015 respectively. He received the B.Eng. degree in Industrial Automation from Hebei Polytechnic University (now North China University of Science and Technology), China, in 2001. From 2001 to 2010, he was a Staff Member and a Section Head with the Department of Academic Affairs, Hebei Polytechnic University, China. His current research interests include computational methods for smart grids; demand response; simulation and modeling optimal control of electricity usage; vehicle-to-grid systems (V2G); renewable energy integration; solar/wind power; optimization theory and applications; and multi-agent systems.

Simerjit Gill (M.A.Sc., P.Eng) is a Licensed Professional Engineer currently working as a Wireless support Engineer at SaskTel. Simerjit has 10 years of combined professional experience in variety of Engineering and Information technology fields. Simerjit holds Master's degree (M.A.Sc.) in Software Systems Engineering from University of Regina and Master's degree in Information Technology from De La Salle University Manila. Simerjit Gill is a registered member of APEGS (Association of Professional Engineers of Saskatchewan).