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Editorial

Electrical and Computer Technology for Effective Diabetes Management and Treatment

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Diabetes mellitus, which is characterized by elevated blood glucose levels (BGLs), affects more than 250 million people globally, making it one of the major chronic medical conditions prevailing today. Expert short-term management is essential to delay or prevent serious long-term complications occurring, such as blindness, amputations, heart disease, and kidney failure. Life-threatening short-term complications can also occur due to both very low BGLs (hypoglycaemia) and very high BGLs (ketoacidosis or hyperosmolar coma).

Technology now plays an increasingly important role in diabetes healthcare and is continuing to revolutionize day-to-day management (and treatment of complications) for millions of people with the condition, improving the prognosis and reducing healthcare costs. Diabetes technology includes the following topics: (1) blood glucose meters, including invasive and noninvasive devices, and meters with artificial intelligence for improved dosing recommendations and also artificial intelligence modeling and educational and advisory software; (2) insulin delivery systems, including pump technology that assist users toward improved physiologic short-term and long-term BGL management; (3) methods which combine a continuous BGL sensor, insulin pump, and control algorithms for creation of an artificial pancreas; (4) retinal screening procedures involving advanced imaging technologies and algorithms; (5) new technologies and signal analysis techniques for detecting diabetic autonomic neuropathy (DAN); (6) advanced therapeutic devices or approaches such as photocoagulation or laser technology for treating retinopathy; (7) sophisticated CAD/CAM orthotic and shoe design techniques to prevent diabetic foot damage through ulceration and improve mobility; (8) sophisticated electronic lancing techniques for obtaining blood samples; (9) communication protocols and systems for implementing a robust and effective telediabetes infrastructure.

This special issue addresses current and proposed technologies for diabetes management and healthcare, with particular regard to recent innovations, and covers a representative selection of the above topics. It reports major achievements by academic and commercial research institutions and individuals and provides an insight into future developments within this exciting and challenging area. A major annual conference which covers all the above topics is Advanced Technologies and Treatments for Diabetes (ATTD), and the next conference will be held in Barcelona, Spain, from 8 to 11 February, 2012 (http://www2.kenes.com/attd/Pages/home.aspx).

Mathematical modeling of plasma insulin and blood glucose is an important research topic, which has major implications in BGL simulation, prediction, and control algorithm design for the artificial pancreas. The first paper, "*Development of AIDA v4.3b diabetes simulator*: *technical upgrade to support incorporation of lispro, aspart, and glargine insulin analogues*," by Lehmann et al., describes a number of clinical and information technology enhancements to the popular and freely accessible AIDA diabetes simulation software. A new model of subcutaneous insulin absorption is incorporated, and this revised approach permits the simulation of insulin profiles for rapidly acting and very long-acting insulin analogues, as well as larger insulin injection doses. The program's continued operation under the Windows XP, Windows Vista, and Windows 7 operating systems overcomes certain display limitations with older versions of the software and extends the useful life of the existing AIDA v4 program.

The second paper, "*Blood glucose prediction using artificial neural networks trained with the AIDA diabetes simulator*: *a proof-of-concept pilot study*," by Robertson et al., describes a pilot study using Elman recurrent artificial neural networks (ANNs) to make BGL predictions based on a history of BGLs, meal intake, and insulin injections. Twenty-eight datasets (from a single case scenario) were compiled from the AIDA diabetes simulator, and encouraging glucose predictions were obtained, due to the model-based nature of AIDA. It was found that the most accurate predictions were achieved during the nocturnal period of the 24-hour cycle.

The third paper, "*Quasi-model-based control of type 1 diabetes mellitus*," by György et al., presents an optimal controller design framework to investigate insulin-dependent (Type 1) diabetes from a control theory point of view. Starting from a recently published glucose-insulin model, a Quasi Model with favourable control properties is developed, minimizing the physiological states to be taken into account. The purpose of the Quasi Model is not to model the glucose-glucagon-insulin interaction precisely, only to grasp the characteristic behaviour such that the designed controller can successfully regulate the unbalanced system. Different optimal control strategies (pole placement, LQ, minimax control) are designed on the Quasi Model, and the obtained controllers' applicability is investigated on two more sophisticated Type 1 diabetic models using two absorption scenarios.

The fourth paper, "*Time-varying procedures for insulin-dependent diabetes mellitus control*," by Sánchez Peña et al., considers the problem of automatically controlling the glucose level in patients with Type 1 diabetes. The objective was to include several important and practical issues in the design: model uncertainty, time variations, nonlinearities, measurement noise, actuator delay and saturation, and real-time implementation. These are fundamental issues to be solved in a device implementing this control. Linear parameter varying (LPV) and unfalsified control (UC) procedures were proposed, and the controllers were implemented with low-order dynamics that adapt continuously according to the glucose levels measured in real time in one case (LPV), and by controller switching based on the actual performance in the other case (UC). Both controllers performed adequately under all these practical restrictions, and the paper concludes with a discussion on the pros and cons of each method.

The fifth paper, "*Regression methods for ophthalmic glucose sensing using metamaterials*," by Rapp et al., presents a novel concept for *in vivo* sensing of glucose using metamaterials in combination with automatic learning systems. The plasmonic analogue of electromagnetically induced transparency (EIT) is used as a sensor, and acquired data are evaluated with support vector machines. The metamaterial may be integrated into a contact lens to measure the ambient glucose concentration through changes in the sensor's reflective optical properties. This could provide a novel method to noninvasively measure BGLs through *in situ* measurements in the eye.

Peripheral diabetic neuropathy is a serious pathological condition which can lead to pain or loss of feeling in the toes, feet, legs, hands, and arms. In advanced cases, this loss of sensation can lead to foot ulceration, which is a major contributing factor for surgical procedures, including amputations. Good engineering design of orthoses for shoes can help prevent those at risk from developing foot ulceration. The final paper, "*Diabetic foot prevention: repeatability of the Loran platform plantar pressure and load distribution measurements in nondiabetic subjects during bipedal standing—a pilot study*, by Zequera Diaz et al., describes a study designed to assess the variability of plantar pressure and postural balance during repeated Loran (pressure) Platform measurements in nondiabetic subjects. These normative studies provide a basis to clinically evaluate diabetic feet for corrective orthotics.

Acknowledgments

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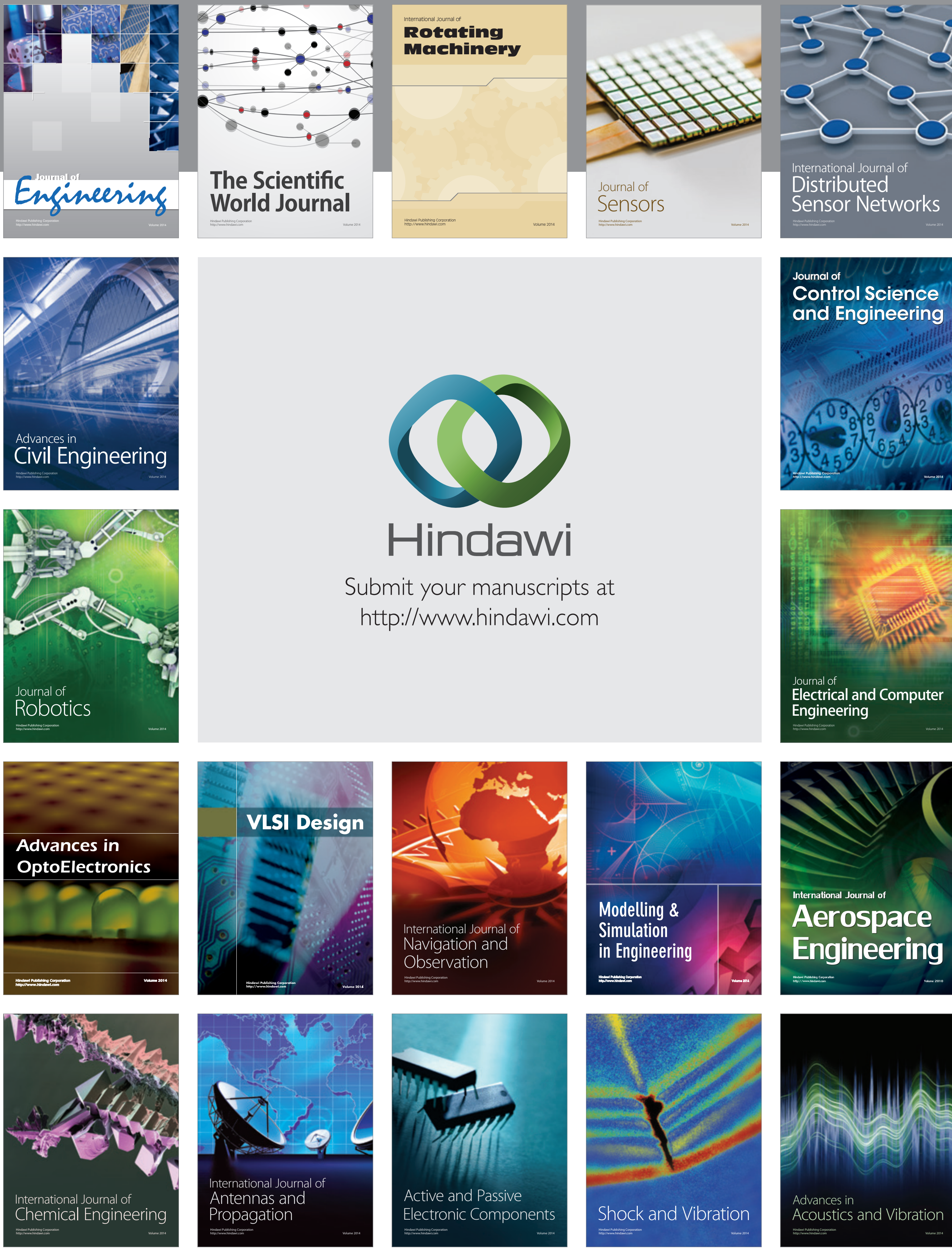
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