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Meanings Must Reflect Facts: A Review on 《Computational Intelligence in Design and Manufacturing》[1)]

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Abstract This is an invited brief review by John Wiley & Sons Inc. on Andrew Kusiak's new book Computational Intelligence in Design and Manufacturing, John Wiley & Sons, Inc., New York, NY, 2000, which reflects my opinion on what constitutes the main components of computational intelligence and my belief that the title of a book must be true statement of its contents.

Key words Computational intelligence, computational methods, design, manufacturing

"When someone speaks truly, what makes his statement true?" This was the opening question in W. V. Quine's classical book Philosophy of Logic (Harvard University Press, 2nd edition, 1986). To me, it has always been a common sense that a true statement simply implies the meaning of the statement and the fact of the matter are identical. As an engineer, I often thought Quine's lengthy discussion to his question is a perfect example of the philosophical extravagance, until I read Kusiak's book: Computational Intelligence in Design and Manufacturing (John Wiley & Sons, Inc., New York, NY, 2000).

I have no doubt that Professor Kusiak speaks truly about his book, but I must say that his title is not a true statement about his book. I believe every reader will think the title means the book deals largely with the application of computational intelligence in design and manufacturing. But after read the book, I am confident that most readers would come to the conclusion that the fact of the matter is quite different from the meaning of the book title. To me, a more appropriate title for this book should be Computational Methods in Design and Manufacturing, not Computational Intelligence (CI) there.

Actually, I am quite surprised that the author did not make effort to define what CI is in his book, not even specifically with respect to the context of his materials. Among 30 pages of the first chapter, only 1 page was spent on CI (Section 1.6), but no attempt was made there to clarify what CI is in the book. It just tells you what wonderful things CI can do, takes "robotics and vision systems" and "simulation" as two examples of CI applications, and mentions "knowledge-based systems", "planning, testing, and diagnostic systems", and "ambiguity resolves attempting to interpret complex, incomplete, or conflicting data" as the CI products that have a significant impact on manufacturing. I have been working with intelligent systems for almost 20 years now, I do agree those are the areas where CI can find applications, but I am sure they are not the focus of the contemporary CI. As a matter of fact, they belong to the applications of traditional artificial intelligence, expert systems, robotics and automation, or more specifically, Intelligent Manufacturing Systems: A well-defined topic the author should be quite familiar with since he had published a book with that title more than a decade ago (John Wiley & Sons, 1990).

My understanding of CI is an area that uses soft computing methods, mainly neural networks, fuzzy sets, evolutionary algorithms, *etc.*, to mimic human intelligence for deci-

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sion-making. Of course, one may argue that so far there is no generally accepted, precise definition of what CI is, but one should respect the consensus on its core materials reached by contemporary educators and researchers. I have asked my students to get all books in our library with a title starting with "computational intelligence". There are 33 of them (more than 80 were found with keyword computational intelligence), including this book and "Computational Intelligence in Manufacturing Handbook" edited by Jun Wang and Kusiak (CRC Press, 2001). Not to my surprise, all the books, except the current one, agree largely with my CI understanding. For example, in his book "Computational Intelligence: An Introduction" (CRC Press, 1998), Pedrycz indicated that the concept of "computational intelligence" was introduced by Bezdek in his paper "On the relationship between neural networks, pattern recognition and intelligence" (*International Journal of Approximate Reasoning*, 1992, 6: 85～107), and stated clearly that "the main components of CI encompass neural networks, fuzzy set technology and evolutionary computation." This statement is supported further by the fact that 17 out of 19 chapters in "Computational Intelligence in Manufacturing Handbook" have either neural networks, fuzzy sets, or genetic algorithms in their titles and the remaining two are about applications of neural networks. Actually, its editors stated that the reason for the handbook was: "despite the large volume of publications devoted to neural networks, fuzzy logic, and evolutionary programming, few address the applications of computational intelligence in design and manufacturing." Note that the last few words constitute precisely the title of the current book.

Now back to the current book in discussion. Among its 17 chapters, only one is devoted to neural networks (Chapter 11, but one may argue to consider the last chapter on data mining as CI related), the whole book has no real discussion of fuzzy logic, no mention of genetic algorithms or evolutionary programming, and to my disappointment, no meaningful applications of CI methods in design and manufacturing at all (only 5 pages, out of total 535 pages, are on applications of neural networks in part recognition). The book is mainly about the mathematical formulations of design, operations, and processes in the perspective of operations research. Few computational experiences are included at the end of some chapters, and they end before they start——a feeling from the way the material is presented. Actually, in the very beginning of the preface, the author stated, "the goal of this book is to present recent advances in modeling and applying computational methods to enterprises." This is why I feel the book should be appropriately titled: Computational Methods in Design and Manufacturing, and in terms of the scope and formulation, I consider the book as a quite solid one under the new title.

The book contains 17 chapters and 535 pages. The first chapter introduces the basic functional areas and related technologies in modern manufacturing, while the second chapter addresses the some basic concepts in AI and knowledge-based systems. Chapters 3 to 10 cover major issues in design and manufacturing, from features, product modeling, process planning, setup reduction, equipment selection, production planning and scheduling, to Kanban systems and group technology. The materials are substantial in their own perspectives but no CI methods are involved. Chapter 11 presents some basic concepts and learning algorithms in neural networks, specifically back-propagation and ART networks, with two examples on their applications in part recognition (totally 5 pages, the whole chapter has 35 pages). It is hard to say this chapter is a good introduction to neural networks. Lippmann's 18-page paper "An introduction to computing with neural nets," (*IEEE Transactions on Acoustics, Speech and Signal Processing*, 1987, **14**(2) cited as the references of this chapter in the book) is a much better introduction in terms of the scope, presentation, organization, and depth. Chapters 12～14 deal with facility and warehouse layout and inventory space allocation. Heuristic algorithms such as computerized relative allocation of facilities technology (CRAFT) are used here but no sign of con-

temporary CI methods. Chapters 15 and 16 discuss "soft issues" in design for agility and supplier evaluation, from design rules, product differentiation, to supplier-customer relationship and building a comprehensive model for suppliers. Again no application of CI methods is found. Finally, Chapter 17 concludes the book with some basic concepts, methods, algorithms and procedures in data mining and a brief discussion of data farming.

Overall, this is a reasonable source book for researchers and graduate students for computational methods, as well as for the possible CI applications in design and manufacturing, but saying the book is about computational intelligence in design and manufacturing is farfetched, and I simply can not make that recommendation to readers.

WANG Fei-Yue Received his Ph. D. degree in Electrical, Computer and Systems Engineering from the Rensselaer Polytechnic Institute, Troy, New York in 1990. He jointed the University of Arizona in 1990 and became a Full Professor of Systems and Industrial Engineering in 1999 and currently is the Director of the Sino-US Joint R&D Center for Intelligent Control Systems, the Director of the Key Laboratory of Complex Systems and Intelligence Science at the Chinese Academy of Sciences. In 1999, he found the Intelligent Control and Systems Engineering Center at the Institute of Automation, Chinese Academy of Sciences, Beijing, P. R. China, under the support of the Outstanding Oversea Chinese Talents Program. His research interests include modeling, analysis, and control mechanism of complex systems; agent-based control systems; intelligent control systems; real-time embedded systems, application specific operating systems (ASOS); applications in intelligent transportation systems, intelligent vehicles and telematics, web caching and service caching, smart appliances and home systems, and network-based automation systems. He has published more than 200 book, book chapters, and papers in those areas since 1984 and received more than 20M from NSF, DOE, DOT, NNSF, CAS, Caterpillar, IBM, HP, AT&T, GM, BHP, RVSI, ABB and Kelon. He received Caterpillar Research Invention Award with Dr. P. J. A. Lever in 1996 and the National Outstanding Young Scientist Research Award from the National Natural Science Foundation of China in 2001. He was the Editor-in-Chief of the International Journal of Intelligent Control and Systems *from 1995* to 2000, and currently is the Editor-in-Charge of Series in Intelligent Control and Intelligent Automation and an Associate Editor of the IEEE Transactions on Systems, Man, and Cybernetics (SMC), IEEE Transactions on Robotics and Automation, IEEE Transactions on Intelligent Transportation Systems (ITS), and several other international journals. He is an AdCom member of IEEE SMC and IEEE Intelligent Transportation Systems Council (ITSC), and the secretary of IEEE ITSC. He was the Program Chair of the 1998 IEEE International Symposium on Intelligent Control, the 2001 IEEE International Conference on Systems, Man, and Cybernetics, the General Chair of the 2003 IEEE International Conference on Intelligent Transportation Systems, and will be Co-Program Chair of the 2004 IEEE International Symposium on Intelligent Vehicles and the General Chair for the same conference in 2005. He was the Vice President of the American Zhu Kezhen Education Foundation, Chinese Association of Science and Technology-USA.

名正才能言顺:评《设计和制造中的计算智能》

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摘 要 该文应 John Wiley & Sons 出版社之邀简评了 Kusiak 教授的新著《设计和制造中的计算智能》.针对什么是计算智能,书名与书内容的关系发表了作者的见解.

关键词 计算智能,计算方法,设计,制造

"当某人讲真话时,是什么使他的话为真?"这是奎因在其经典名著《逻辑的哲学》(哈佛

出版社,第二修正版,1986 年)的开篇问题. 我一直觉得真话不过就是话中隐含的意思与话所指的事实相符而已,这是公认的常识,没有什么可说的. 作为一个工程师,我常想奎因关于这个问题的长篇大论是哲学家小题大做的一个绝好的例子,直到我读了 Kusiak 教授的专著《设计和制造中的计算智能》(Computational Intelligence in Design and Manufacturing, John Wiley & Sons 出版社,纽约,2000 年).

作为设计和制造方面的国际著名和多产专家,我毫不怀疑 Kusiak 教授在书中说的都是真话和事实,但我也必须说真话:其书名与其书的内容不符. 我相信每个读者都会从书名认为本书主要涉及计算智能在设计与制造中的应用,但读过此书后,我也相信多数读者会觉得此书内容反映出的事实与其书名所隐含的意思相去甚远. 对我来说,本书更恰当的名称应当是《设计和制造中的计算方法》,即 Computational Methods,而不是 Computational Intelligence.

更使我非常不解的是,作者并没有试图在本书中定义什么是计算智能,甚至就连计算智能在这本书中的具体内容是什么也没有说明. 在第一章的 30 页中,只有一页涉及计算智能(见 1.6 节),但却没有说清计算智能到底在本书中是指什么. 短短的一页,只告诉你计算智能有多么美妙,举了"机器人及视觉"和"模拟"作为计算智能的两个例子,提了"基于知识的系统","计划、检验和诊断系统"以及"试图解释复杂、不完备或冲突数据的多义辨析"作为在制造方面有重大影响的计算智能的几个产品. 从事智能系统的研究差不多也有快 20 年的历史,我当然同意这些都是计算智能可以发挥作用的领域,但我也确信它们并不是当今计算智能的焦点方向. 事实上,它们属于传统的人工智能、专家系统、机器人与自动化,或更加具体地说,属于《智能制造系统》——一个十分明确并且作者也应非常熟悉的领域,因为十多年前他曾以此为书名由同家出版公司发行过一本专著(John Wiley & Sons, 1990).

我对计算智能的理解是:采用各类软计算方法,主要是神经元网络、模糊逻辑和遗传进化算法等去模拟人类决策智能的一个新兴领域. 当然,人们可以认为当前还没有一个精确的、被广泛接受的什么是计算智能的定义,人人都有权利提出自己的看法. 但一般人,特别是从事本领域的专家学者,应尊重由当今教育者和研究者就其核心内容所达成的共识. 我让自己的学生去我们图书馆查阅了所有书名含有"计算智能"的书,共找到 33 本(但按主题字"计算智能"可以找到 80 多本),包括本书和《制造中的计算智能手册》(Computational Intelligence in Manufacturing Handbook, Wang 和 Kusiak 编辑,CRC Press, 2001). 除了本书之外的所有的书,差不多都与我对计算智能的理解一致. 举例来说,在其专著《计算智能引论》(Computational Intelligence: An Introduce, CRC Press, 1998)中,Pedrycz 教授指出"计算智能"的概念是由 Bezdek 首次在其论文"关于神经元网络、模式识别和智能之间的关系"(On the Relationship between Neural Networks, Pattern Recognition and Intelligence, International Journal of Approximate Reasoning, 1992, 6:85~107)中引入,同时声称:"计算智能的主要组成部分包含神经元网络、模糊集合技术和进化计算". Kusiak 共同编辑的《制造中的计算智能手册》一书也进一步地支持了这一断言:此手册共有 19 章,其中 17 章的章名中含有神经元网络、模糊集合或者遗传算法,剩下的两章是关于神经元网络应用方面的论述. 尤其是,手册的编辑说明出版手册的原因是"尽管有大量专门的神经元网络、模糊逻辑和遗传编程的出版物,但其中很少讨论设计与制造中计算智能." 不知编辑是否注意到这里最后的几个字恰好就是本书的题目.

回到本书的讨论. 在其全部的 17 章中,只有一章专门用于论述神经元网络(第 11 章,当然人们也可争论说最后关于数据挖掘的一章也可作为计算智能),全书没有真正讨论模糊逻辑,没有提及遗传算法或进化计算,更使我失望的是,这本书其实根本就没有涉及有意义的计算智能应用. 我讲此话的事实依据是:在全书的 535 页之中,仅有 5 页,差不多就是百分之一,是关于能同计算智能挂上钩的神经元网络在部件识别中的应用. 这本书主要是关于设计、运作和过程中运筹学的数学公式和表述. 只有某些章节在其最后部分涉及计算实例,而且往往是在没有开始之前就停止了——这是从有关材料的表达方式中所感受到的. 其实,在前言的一开始,作者就声称:"本书的目的是表述在企业中应用计算方法的最近进展." 这也是我感到本书应正名为《设计与制造中的计算方法》的原因之一. 就其范围和表述而言,我认为在新的名称下,它将是一本扎实的著作.

本书共 17 章 535 页. 第一章引人现代制造的基本功能领域和相关技术. 第二章讨论人工智能和基于知识系统的一些基本概念. 第三章至第十章包含设计和制造中的主要课题,从特征、产品建模、过程规划、装置减少、设备选择、生产规划和调度到 Kanban 系统和群组技术. 这些材料十分充实但不涉及计算智能. 第十一章给出了神经元网络学习算法的一些基本概念,尤其是 BP 和 ART 网络,并提供了它们在部件识别中的两个应用例子(共 5 页,本章共 35 页),很难说这是对神经元网络的一个很好的介绍. 尽管有许多缺点,Lippmann 十多年前的 18 页"科普" 文章"神经元网络计算介绍"(An Introduction to Computing with Neural Nets, *IEEE Transactions on Acoustics, Speech and Signal Processing*, 1987, **14**(12)本书本章的参考文献之一)在范围、表述、组织和深度方面都要好得多. 第十二到十四章涉及设施和仓库布置和库存空间分配. 这里引用了计算机化的相对设施分配(CRAFT)之类的启发式算法,但没有当代计算智能的痕迹. 第十五章和十六章讨论灵巧设计和供应商中的"软课题",从设计规划、产品区别到供应商客户关系和建立供应商的全面模型,但同样也没有找到计算智能的应用,尽管在理论上这些都是最该使用计算智能的地方. 最后,第十七章以数据挖掘中的一些基本概念、方法、算法和步骤,以及数据农场(Data Farming)的简短讨论结束本书.

总体而言,这是适合于研究人员和研究生的一本关于设计和制造中的计算方法以及可能的计算智能方法应用的较好资源书,但将本书说成是设计和制造中的计算智能,可能的确是过分了,我不能在如此的标题下向读者推荐本书.