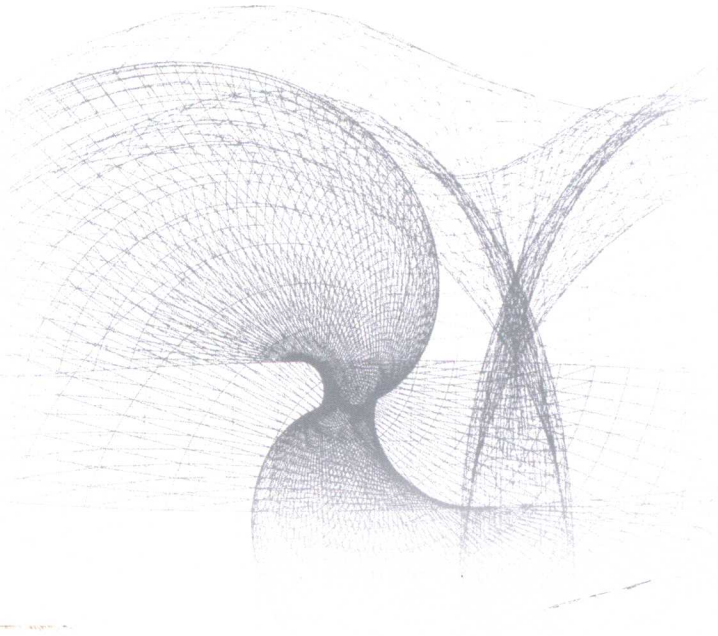
UNCONVENTIONAL CRISIS IDENTIFICATION AND PRE-CONTROL BASED ON IMMUNOLOGY

基于免疫学的非常规突发事件识别和预控

杨 青　杨 帆　刘星星　王 湛　著



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内 容 简 介

本书是作者在总结借鉴免疫学、多智能体建模和仿真、应急管理等理论和方法的基础上编写的，主要包括：突发事件与非常规突发事件的基本理论，突发事件应急管理与非常规突发事件识别和预控的基本理论，免疫学与人工免疫系统，计算实验和建模方法的基本理论，基于免疫学的非常规突发事件识别和预控理论框架，非常规突发事件基因库，基于免疫学的非常规突发事件风险识别，非常规单一突发事件演化与预控，非常规突发事件的多次联动演化与预控，案例仿真及其情景推演等。

本书可以为危机与灾害应急管理、安全科学与工程、公共事业管理、社会科学、计算机科学、信息科学、智能科学等领域的相关人员提供参考，也可以作为相关专业研究生和高年级本科生教材。

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前　言

SARS 事件、汶川地震、甲型 H1N1 流感、埃博拉疫情等非常规突发事件给人类社会带来了巨大灾难，引起世界各国的高度重视。如何进行这类非常规突发事件的应急管理，是极具挑战性的重大课题，对构建突发事件应急管理防御体系提出了新要求。

故此，我们从生物免疫学的全新角度，结合集成管理科学、生命科学和信息科学，构建基于免疫学的非常规突发事件应急管理多智能系统，形成非常规突发事件应急管理的新理论和新方法，充实应急管理体系，丰富发展应急管理理论，强化基于免疫学的非常规突发事件风险识别、预控仿真理论研究，以期提高我国该领域研究在国际上的地位与影响力。

本书是在国家自然科学基金重大研究计划培育项目“基于免疫学的非常规突发事件应急管理主动防御多智能系统”（项目批准号：91024020）等课题研究的基础上编写的。笔者在总结借鉴免疫学、多智能体建模和仿真、应急管理等理论和方法的基础上，按照“理论框架建构—风险识别器多智能体优化—风险预控多智能体优化”的逻辑思路，对非常规突发事件识别和预控进行了深入系统的研究。主要研究内容包括：突发事件与非常规突发事件的基本理论，突发事件应急管理与非常规突发事件识别和预控的基本理论，免疫学与人工免疫系统，计算实验和建模方法的基本理论，基于免疫学的非常规突发事件识别和预控理论框架，非常规突发事件基因库，基于免疫学的非常规突发事件风险识别，非常规单一突发事件演化与预控，非常规突发事件的多次联动演化与预控，案例仿真及其情景推演等。

本书的创新点主要有三个：一是提出了基于免疫学的非常规突发事件识别和预控理论框架。这个理论框架假设抗原 Agent 代表非常规突发事件风险，是风险识别器 Agent 和预控方案 Agent 针对的对象；风险识别器 Agent 和预控方案 Agent 将针对特异性的非常规突发事件风险分别生成，并通过克隆选择作用，不断淘汰“亲合度”低的，补充进新的“亲合度”更高的，直至获得进化的最优风险识别器和预控方案。二是构建了基于免疫系统的非常规突发事件风险识别模型。在揭示了非常规突发事件三类演化机理和九种特质的基础上，构建了“三九”双层非常规突发事件基因框架。提出了风险识别器抗体向非常规突发事件抗原进化的

理论，建立了风险识别的亲合度、抗原清除效果、风险识别器数量和能量等识别标准体系及其模型，通过计算实验和算例分析，验证了研究成果的科学性和可行性。三是建立了非常规突发事件的演化与预控模型。建立了非常规突发事件的演化模型和主动防御的接种—隔离—释放多 Agent 模型，提出了非常规突发传染病事件的 SEIR-II 演化和预控模型以及基于能量随机分布的特大森林火灾演化与能量释放预控模型，通过对甲型 H1N1 事件和 2009 年澳大利亚特大森林火灾等案例的仿真分析和情景模拟推演，验证了模型的科学性和实用性。

这些创新的成果为建立具有中国特色的应急管理防御新体系做出了贡献，丰富和发展了应急管理理论，为政府在复杂多变的环境中实施科学高效的管理、提高执政能力从而保障公共安全提供了新的理念和范式，具有重要的理论价值和实践指导意义。

参加本项目研究工作的还有：马慧敏、黄炜、胡艳、施亚能、于艳玲、王黎、张典、彭予等。

由于作者水平有限，书中不妥之处在所难免，敬请读者批评指正。

杨　青

2014 年 10 月

武汉理工大学

Preface

SARS, the "5.12" Wenchuan earthquake, Novel influenza A (H1N1), Ebola virus, and other unconventional crisis have continuously brought about huge damages, to which great importance is being attached by the countries and the international society. How to respond and manage the unconventional crisis effectively is a challenging problem the defense system of emergency management is faced with.

Witha combination of immunology, management, life sciences and information science, developing an immunology-based multi-agent system for the unconventional crisis management will contribute to a new theoretic-methodological basics of unconventional crisis management. It can also enrich the emergency management systems and theories. Furthermore, the study can promote the development of an immunology-based theory framework for the unconventional crisis identification, pre-control, and simulation. All this will improve China's international status and influence in this field.

The monograph, *Unconventional Crisis Identification and Pre-Control Based on Immunology*, is based upon the previous work (The Active Defense Multi-Agent System for Unconventional Crisis Management Based on Immunology) funded by National Natural Science Foundation of China (No. 91024020). The authors followed such thinking as the theoretical framework construction, risk recognizer optimization, and pre-control proposal optimization. In line with a combination of immunology, multi-agent system development and the simulation, emergency management, and their related theories, the authors conducted a systematic research on the unconventional crisis identification and pre-control. Specifically, the following issues are covered: fundamentals of emergency and unconventional crisis, fundamentals of emergency management and unconventional crisis identification and pre-control, immunology and artificial immune system, fundamentals of computational experiments and model development, theoretical framework for unconventional crisis identification and pre-control based on immunology, gene pool of unconventional crisis, unconventional crisis identification based on immunology, single unconventional crisis evolution and pre-control, evolution and pre-control of the unconventional crisis-crisis interactions, and the simulation.

This study achieved three main innovation points. ①Propose a concept framework for the unconventional crisis identification and pre-control based on immunology. It is assumed that the antigen agent functions as the unconventional crisis which is what the risk recognizer agent and the pre-control proposal agent respond to. Against a certain unconventional crisis, the risk recognizer agents and pre-control proposal agents are formed. And by the clonal selection, the evoluted and optimal risk recognizers and pre-control proposals will finally be achieved. ② Construct an immunology-based unconventional crisis identification model. The nine genes of unconventional crisis and its three evolution rules are highlighted. This work also presents the theory about the antibody evolution of risk recognizer towards the antigen of unconventional crisis, and develops a standard system of the affinity of risk identification, the cleanup effect of antigen, the amount and energy of the risk recognizers and the related models. And a computational experiment is conducted to testify these results. ③Build an unconventional crisis evolution and pre-control model. Specifically, an unconventional crisis evolution model and an active defense multi-agent system are set up based on immunization, isolation and energy release. In addition, an SEIR-II model for the unconventional infectious disease crisis, and a random-energy-based evolution and pre-control model for the catastrophic forest fire are presented. They are all testified respectively by a simulation and deduction of the real events.

These achievements will contribute to the construction of China's adaptive active defense system for emergency management, develop the emergency management theories, and provide the government with a new concept and paradigm to conduct effective management in a complex environment and to promote the governance capability to ensure public security.

Being subject to the limits of our ability, inadequacy is inevitable in the book. The authors would like to welcome criticism and suggestions from readers.

Prof. YANG Qing
Wuhan University of Technology
October, 2014

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