博士論文（要約）

Analyzing Post-disaster Recovery Phenomena through the Design and Development of an Agent-based Recovery Simulation Model:
A New Approach towards Re-thinking Disaster Recovery Mechanisms

（マルチエージェントモデルによる復興モデルの構築と復興現象の解明
～災害復興メカニズムの再考に向けた新たなアプローチ～）

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The process of disaster recovery involves the dynamic interaction of multiple factors which often remain hidden from the surface. Furthermore, due to empirical limitations, recovery outcomes are often superficially understood. To have an effective recovery policy it is essential that policy makers recognize this dynamic aspect of disaster recovery. This research study develops a multi-agent simulation model for recovery which allows the clarification of inter-related aspects of recovery such as pre-disaster community characteristics, damage type, and the recovery policies applied; thereby enabling the comprehension of the recovery process holistically. Furthermore, it proposes a framework for the holistic evaluation of recovery in terms of Area Recovery and Individual Recovery using which the simulation results are analysed in more detail showing characteristic differences and patterns of recovery depending on the pre-disaster situation.

Chapter 1 Introduces the study with a rationale for a new approach towards disaster recovery. It poses the current problems with post-disaster recovery including the tendency to generalize policies; lack of understanding of the long-terms effects; lack of holistic understanding; reformation of recovery policies which only occur after disaster; and the uncertainty associated with recovery. It then discusses the importance of this research and how it addresses each of the above mentioned aspects. Following this, the overarching research question and sub-questions along with the objectives of the research are stated. The scope and limitations of the study as well as the methodology is discussed here.

Chapter 2 reviews the literature on disaster recovery to understand the challenges associated both with post-disaster recovery itself and the field of recovery research acknowledging the pre-existing research in the discipline. Examples of issues observed from the Hanshin-Awaji Earthquake, Hurricane Katrina, Sichuan-Wenchuan Earthquake, Indian Ocean Tsunami, and Canterbury Earthquake are discussed in regards to three overarching considerations: 1) socio-spatial phenomena, 2) Policy & practice issues, and 3) Evaluative measurements of recovery. This sets the context for the development of the recovery model.

Chapter 3 develops the conceptual framework of the proposed simulation model while explaining the steps taken and postulates applied to form the model. The composition of the simulation environment (areas and agents) and the abstract representations of the real-life situations (community, infrastructure, employment, cost, and facilities) in the model are discussed. The inbuilt dynamic parameters of Ideal Attractiveness and Tolerance/Acceptance are also discussed along with how these variables are used for decision-making of migration locations (returning to disaster area, waiting at temporary housing, moving to external area).

Chapter 4 explains the simulation experiment design and methodology along with the boundary conditions and limitations of the model. The need for and development of 'generic data sets' are discussed followed by the setting of 'typical city' values and variation considerations. Likewise, the representations of the 'general recovery policies' in terms of the model parameters are also identified and the meanings of their possible deviations considered.

Chapter 5 lists the observations and trends understood from running the simulation model leading to discussions of the general validation of the model against empirical knowledge. The general points of consideration are: the relative impacts of recovery parameters; flow of migration process; the relationship between out-migration and final rate of return to the disaster area; the importance of spatial planning; the competition between the qualities of the neighboring external area and the recovery of the disaster area; the importance of the employment rate recovery for increasing the return rate of people; and the influence of sharing a recovery plan with the citizens. Furthermore, the aspects of experiment results which may be worthy of further consideration through detailed analysis are also considered.

Chapter 6 develops a holistic recovery evaluation framework for evaluating recoveries based on the simulation inputs of the model. It discusses the possibility of analyzing recovery from the consideration of three major axes: 1) Individual Recovery; 2) Area Recovery; and 3) Cost of Recovery. The qualitative implications of the different locations of the possible points on the graph are discussed along with the limitations of its use.

Chapter 7 utilizes the recovery evaluation framework to analyze seven different simulation experiment results in terms of recovery parameter inputs. The experiments conducted are based around four different factors including 1) community composition (primary and secondary characteristics of agents); 2) temporal change of certain recovery policies (speed of recovery and prioritization of aspects); 3) pre-event and recovery plan organization of facilities and agents; and 4) the sensitivity of the model to minimal changes in parameters. Through these experiments it is shown how the framework can be used to determine the best policies (though in abstract terms). The experiments also reveal some new trends and insights which can have implications for future recovery planning considerations.

Chapter 8 summarizes the new findings reconsiders the insights gained from the simulation experiment analyses in the light of the current recovery progress in the wake of the 2011 Great East Japan Earthquake and what can be said of its future outcome.

Chapter 9 outlines the contributions of this research, policy recommendations and future directives for the study. The overall contributions of this research can be summarized as: 1) providing a method which enables the exploration of recovery mechanisms; 2) development of an Recovery Evaluation Framework to analyze simulation outputs for identifying better recovery policies with example analyses based on three essential focal points (community composition, temporal change, and spatial organization); 3) deciphering of particular recovery outcomes using 1) & 2) to reveal the insights discussed above. This research is a novel undertaking in the current field, and holds great promise and scope for future advancement of both the prototype model and the framework for analysis to assist in informing future recovery policies.

As the directives for future studies, refinement of the prototype disaster recovery simulation model developed is required. In addition, better consideration of the uncertainty factors need to be taken into account. Detailed development of the proposed disaster recovery evaluation framework for several cases is also necessary to enable its applicability to actual field of urban planning. It is expected that further analysis in consideration with the sensitivity of the parameters of the model will also enable the consideration of the most important parameters in recovery which can lead to further applicable studies.