論 文 の 内 容 の 要 旨

論文題目　Upcycling Non-standard Resources as Architectural Elements through Adaptive Digital Fabrication
(非規格材を建築要素へ高付加価値化する適応的デジタルファブリケーション)

氏　　名　吉田　博則

Today, almost all modern buildings are constructed with standard materials. Although standard materials make design and construction plausible, current material flow is down-cycling from unique individual elements to regular, uniformed pieces. Upcycling promotes creative re-purposing without processing them and has been explored by architects and HCI (Human-Computer Interaction) researchers. In traditional architecture, we can find a similar use of materials but with natural raw resources, e.g., curvy wooden beams and irregularly shaped rocks in masonry walls. In the past, the shapes of these materials are conserved due to limited standardization technologies and materials are more irregular than used products. However, they share a similar problem: Both fabrication processes are required to be more flexible and dynamic for irregular and uncertain material behaviors.

In this thesis, we define non-standard materials and upcycle them for architectural elements. Instead of being retrospective, we propose ”adaptive fabrication” as a conceptual framework to explore methods for handling non-standard materials. By augmenting material-awareness for humans and machines, adaptive fabrication recognizes the richness of materials, at the same time, enables them to handle these materials with complex properties. Throughout this thesis, we implement material-aware design and fabrication tools, aim to solve the challenges in resourceful and scalable manners. Three different kinds of materials are selected as case studies, and we evaluate developed tool for each case within the framework of adaptive fabrication, described as follows.

1. Taking rejects from chopstick production lines, we implement a human-assisted additive manufacturing system for large scale architectural pavilion. Material-aware

design is achieved by taking accumulated sticks as design and modeling the material with unit-volume tested in advance. Material-aware fabrication achieved by real-time projection mapping on work for guiding human workers.

2. Focusing on various shapes of tree branches, we implemented a design and fabrication system for irregularly shaped branches. The material-aware design was achieved by scanning and extracting skeleton and contours in advance. Material-aware fabrication was implemented by human-in-the-loop fabrication, where humans focus on positioning branches on a simple CNC (Computer Numerical Control) milling machine.

3. Within a robotic masonry system placing irregularly shaped stones, my focus here was planning how to place. The material-aware design was achieved by the offline scanning and alignment of real and simulated stones. Material-aware fabrication was implemented by turn-taking observation after placement and simulation of the next placement.