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Innovation by Multi-technology Fusion：The Case of the Intellectual Robotics Industry

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Abstract

It is theoretically argued that multi-technology fusion has a life cycle like any product innovations. It begins as a researcher starts socialization in doing a research work to integrate a different technological knowledge. Then, an innovation stage emerges as the researcher generates a new knowledge that creates new functions or new product. Innovative knowledge become a routine knowledge as the researcher stops to add a new things moving to a stabilization stage that finishes a life cycle of multi-technology fusion.

Innovation of intelligent robotics has a system nature with multi-technology fusion because various professionals and institutes play roles in creating new technology. It starts as a researcher with a cognitive map on the one technology in a firm does interact with another researcher holding another cognitive map on a university or a research institute. Their interaction evolves to collective learning with collective cognitive maps. This collective learning is distinctive feature of robotics innovation by multi-technology fusion in which core element is knowledge activities such as acquisition, assimilation, integration and creation of different robotics technology for a new robot.

This paper aims to understand the mechanism and patterns of R&D activities among different organizations like universities, research institutes and firms for an innovation of robotics technology through multi-technology fusion. It investigates the intelligent robotics industry in both Korean and Japan by analyzing a meso-level statistics and taking interviews with professional people.

1. Introduction

○ Trends of Technological Innovation

- Increasing complexity of products, requiring increasingly heavy investments in the plant needed to manufacture new products
- Miniaturization of devices, resulting in increased information transmission capacity, denser storage capability
- Advances in digitizing and encoding techniques, allowing networks to carry voice, data and image signals
- Advances in materials technology through the development of sophisticated architecture (thin layers, 3D etc.) and compounds
- Integrated nature of innovation and new generation products is now increasingly widely acknowledged

○ Multi-technology fusion plays a critical role in the innovation of next generation products to gain competitive advantage at the level of nations, regions and firms

"The success achieved by German companies in world markets may be attributed to their ability to combine different technologies and systems. Such an approach is becoming increasingly crucial in a context of structural change in the world economy" (OECD, 1993).

- Multi-technology fusion is ways to Generate Synergy Effect in Firms: Competition is a power generated by confronting; Cooperation is a power generated by doing together; but Co-creation is a hybrid-power generated by creating together.

○ This paper aims to understand the mechanism and patterns of R&D activities among different organizations like universities, research institutes and firms for an innovation of robotics technology through multi-technology fusion. It investigates the intelligent robotics industry in both Korean and Japan by analyzing a meso-level statistics and taking interviews with professional people.

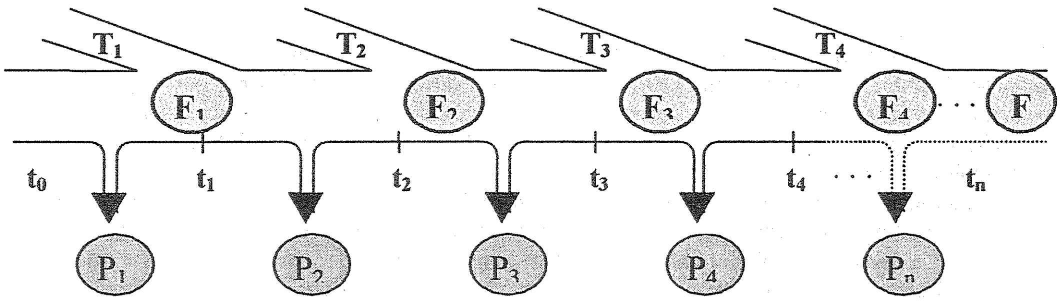
2. Theoretical Discussion on Innovation by Multi-technology Fusion

○ Definition: vertical & horizontal integration of diverse technologies

- Vertical integration: to achieve tech-fusion innovation, firms should concentrate on some core technologies that can enjoy competitive advantage, and upgrade their level of innovative capability

- Horizontal integration: firms should deep into their competitive fields of technologies, at the same time broad the scope of their technological specialization that can interact with partner companies

It is theoretically argued that multi-technology fusion has a life cycle like any product innovations. It begins as a researcher starts socialization in doing a research work to integrate a different technological knowledge. Then, an innovation stage emerges as the researcher generates a new knowledge that creates new functions or new product. Innovative knowledge become a routine knowledge as the researcher stops to add a new things moving to a stabilization stage that finishes a life cycle of multi-technology fusion.



$t_1, \cdots\cdots t_n$: time

$T_1, T_2, \cdots\cdots T_n$: elements

$F_1, F_2, \cdots\cdots F_n$: functions of product

$P_1, P_2, \cdots\cdots P_n$: new products

Figure 1: Innovation Process of MTF: Concept

Modern innovation of technology has a system nature with multi-technology fusion because various professionals and institutes play roles in creating new technology. It starts as a researcher with a cognitive map on the one technology in a firm does interact with another researcher holding another cognitive map on a university or a research institute. Their interaction evolves to collective learning with collective cognitive maps. This collective learning is distinctive feature of contemporary innovation by multi-technology fusion in which core element is knowledge activities such as acquisition, assimilation, integration and creation of different technology for a new product.

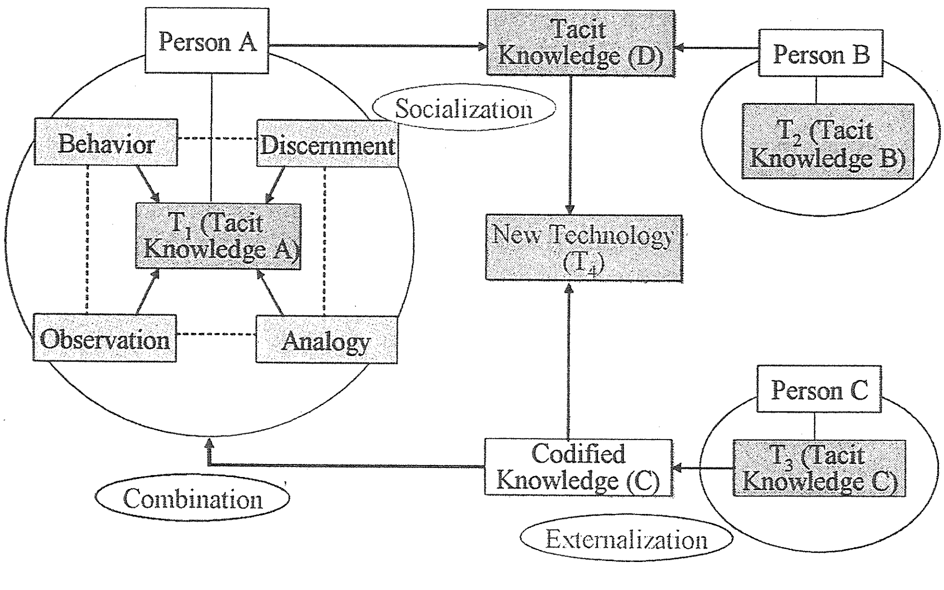
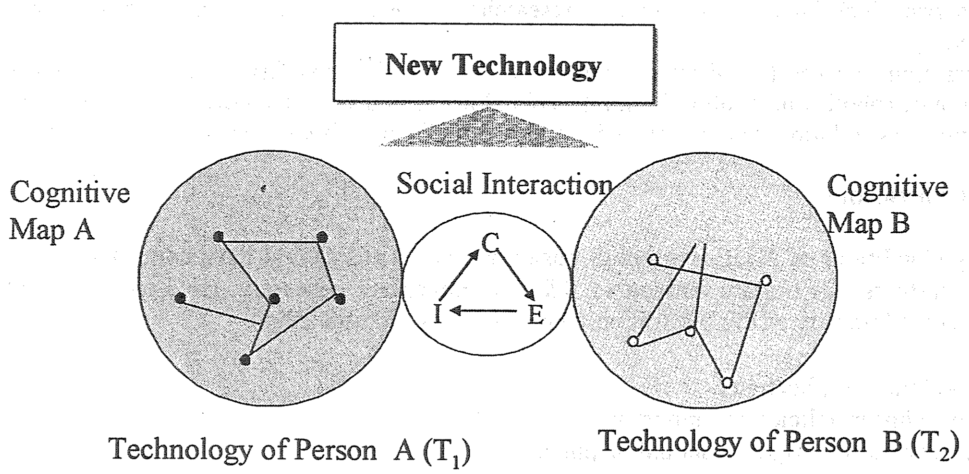


Figure 2: Multi-technology Fusion Mechanism



Notes: C (communication), E (Evaluation), I (Integration)

Figure 3: New Technology Creation through Multi-technology Fusion

3. Empirical Investigation into the Intelligent Robotics Industry

Innovation of robotics has a system nature with multi-technology fusion because various professionals and institute play roles in creating new robotics technology. It starts as a researcher with a cognitive map on the one

Year	Intellectual Robotics Industry	Government R&D Investment (Japan)	University and PRI R&D	Innovations of Other Industries
1970	First robot boom □ Spot welding by robots in automobile assembling		Emergence of robotics engineering □ Technology to control location of robot arms □ 2 dimension view sensor and power sensor □ Scalar robots □ Walking of 2 legs robots	□ Development of 16bit micro processors
1980	Supply of industrial robots □ Arc welding by robots in auto makers □ About 100 firms entered into robotics business □ Control robots with view sensor (used in wire bonding)	1982~89 (8 years) Development program of working robots under extreme condition (about 18 bill. yen)	Manipulation under extreme condition □ Multi-angle walking □ Remote intellectual operation □ Telecom perceived □ Model based intellectual □ Humanoid tools (2 legs robots, multi-joint manipulator, sensing robots)	□ Small, high performance micro processors □ Semiconductors sensors (CCD etc.) □ Start R&D on artificial intelligence
1990	Mass supply of industrial robots (80 thousands in 1991) □ Prevailed in automobile and electrical industry □ Exits from robotics business □ High growth in such robot markets as shipbuilding and electronic parts assembling (60 thousands, multi millions yens sales)	1991~2000 (10 years) Development program of micro machines (about 25 billion yens) 1998~2002 (5 years) Private-public cooperation R&D program	Humanoid (cognition) and micro machines □ Remote operation by VR □ Boarding of small computers □ Sensing robots □ Multi-function robots □ Micro robots □ Behavioral intelligence	□ Low price of desk computers □ VR technologies □ Emergence of internet technology
2000	Second robot boom □ Application to new areas □ Fusion of RT, IT, NT □ Human-type platform □ Intellectual entertainment	Robotics system technology (about 5 billion yens) Cooperative R&D program (among industry, university, and public research institute)	Future fundamental robotics technologies (seed development)	□ Expansion of internets

Figure 4: Diffusion and Fusion of Different Technological Knowledge in the Innovation of Robotics Technology

technology in a firm does interact with another researcher holding another cognitive map on a university or a research institute.

Their interaction evolves to collective learning with collective cognitive maps. This collective learning is distinctive feature of robotics innovation by multi-technology fusion in which core element is knowledge activities such as acquisition, assimilation, integration and creation of different robotics technology for a new robot.

4. Temporary Conclusions

○ Necessary Conditions of Multi-technology fusion are (1) Firms should have competence in some field that can share with partners, (2) Certain amount of R&D resources are necessary, (3) Long-term stability of R&D environment, and (4) Intensity of R&D effort based on strong prior knowledge

○ Temporary Policy Implications
- Innovative cluster policies are important
- Diverse networking programs should be pursued
- Various industry-university cooperation initiatives are important
- Possible directions of policy for public R&D organizations
  - Autonomous and diversity should be emphasized
  - Promote self autonomy and innovation management of R&D teams
- Building up national innovation system to encourage creative learning
- Education institution and government R&D programs should be harmonized suitable for cooperative R&D

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