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# The AI Application and Talent Demand of Taiwan High-Tech Manufacturing Industry

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***Abstract*—**This paper uses both quantitative and qualitative approaches to survey the current status of AI-related applications and the structure of key AI jobs in Taiwan's high-tech manufacturing industry, as well as the demand for professional AI talents, skills, and training. The result shows that AI applications and talent demand vary from different industries in many aspects, including technologies used, talent structure, and training methods. This paper serves as a reference for the government to establish appropriate talent training programs, and to reduce the demand gap for professional AI talents in Taiwan manufacturers.

***Keywords*—**Artificial intelligence, manufacturing, talent, training.

## I. Introduction

WITH the accumulation of big data, development of hardware performance and improvement of algorithms in recent years, Artificial Intelligence applications have gradually overcome technical limitations and penetrated into every corner of the human society, including sectors like manufacturing, healthcare, retail, financial, transportation, education and agricultural [2].

Today, AI applications are rapidly moving toward commercialization and having a significant impact on all industries [3]. They continue to expand, particularly into electronics and information industries that have invested the most in AI. A study done by Accenture PLC predicts that the growth of capital and population will no longer supports the expected growth of global economy while AI applications can fill the gap and have the potential to boost enterprise productivity by nearly 40% [1]. In the foreseeable future, human society and lifestyle will be fundamentally transformed by AI as much as the invention of electricity and the Internet.

Responding to the changes in the industrial environment, this study aims to understand the demand of Taiwan's high-tech manufacturing industry for AI specialists to develop relevant talent training programs and bridge the gap between demand and supply.

## II. Investigation Plan

### *A. Investigation Scope*

High-tech manufacturing industry is a pillar for Taiwan's economy. In 2020, its output value was as high as USD$1.6 trillion [4]. The firms investigated in this study through a questionnaire and qualitative interviews are high-tech manufacturing companies approved and registered by the competent authority, which belong to the categories of "Electronic Parts and Components Manufacturing (Mid-Category 26)" and "Computers, Electronic and Optical Products Manufacturing (Mid-Category 27)", in order to understand the AI applications and demand for AI talent in Taiwan's high-tech manufacturing industry.

### *B. Investigation Method*

Through both qualitative interviews and a quantitative questionnaire, this study focuses on high-tech manufacturing firms that have invested in the development of AI applications and expects to gain insights into current demand and future trends for key AI specialists as well as the status quo and future prospects for AI applications.

(A) Interviews

a. Scope: representative high-tech manufacturing firms within the investigation scope that have invested in the development of AI applications.
b. Target: people in charge of AI applications, top executives, human resources managers or hiring managers.
c. Method: face-to-face interviews and online meetings.
d. Content:
(a) AI applications of the interviewed firms.
(b) AI talent demand and training methods of the interviewed firms.
(c) AI-related policy recommendations of the interviewed firms.
e. Duration: May 1, 2020 – August 31, 2020.
f. Number of Firms Interviewed: ten companies and one association.

(B) Questionnaires

a. Scope: The top 600 companies with the highest revenue in approximately 3,500 approved and registered firms, which are members of the Taiwan Electrical and Electronic Manufacturers' Association, Taiwan Semiconductor Industry Association, Taiwan Electronic Equipment Industry Association, Taiwan Optics Association, and other related associations.
b. Target: people in charge/top executives, human resources managers or hiring managers.
c. Method: mainly by email and post; partially by fax, phone and interview.
d. Content:
(a) basic company information
(b) human resources status
(c) key job vacancies

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(d) talent management transformation
(e) demand for talent training
e. Duration: May 15, 2020 – July 31, 2020.
f. Response: 155 effective questionnaire copies (response rate: 23.2%).

## III. Development of AI Applications in Taiwan's High-Tech Manufacturing Industry

This study focuses on high-tech manufacturing companies in the categories of Electronic Parts and Components Manufacturing (Mid-Category 26) and Computers, Electronic and Optical Products Manufacturing (Mid-Category 27) and investigates their business operation, AI talent demand and AI talent training methods. Among the collected samples, Electronic Parts and Components Manufacturing accounts for 71% and Computers, Electronic and Optical Products Manufacturing for 29%, generally corresponding to the population.

### *A. Overview of AI Applications*

This study divides mainstream AI technologies into 5 categories [5]: computer vision (e.g., industrial AOI, facial recognition), natural language processing (e.g., word processing, speaker recognition), data analysis and inference (e.g., failure prediction, production line optimization), motion control (e.g., robotic arms, automated driving) and data capture and cleaning (e.g., web crawler, data labeling) in order to understand which mainstream AI technologies are being used by the firms.

The result is shown in Fig. 1. About 1/4 of the high-tech manufacturing firms investigated use computer vision as their primary AI applications, followed by data analysis and inference. One reason can be that the firms investigated primarily apply AI in quality inspection and process optimization. Therefore, they invest more in these two areas. Additionally, 34.2% responded that they have no AI applications or their AI applications are under development.

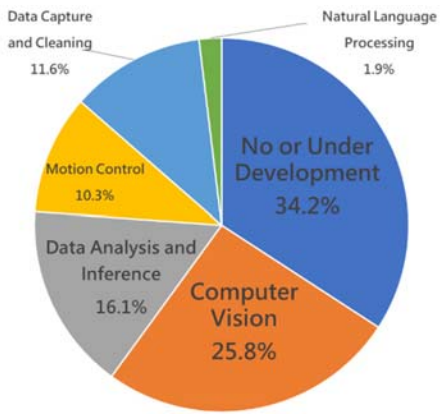


Fig. 1 The percentages of AI technologies used by high-tech manufacturing firms

### *B. Number of AI Specialists*

In terms of the number of AI specialists, 27.7% of the companies investigated have employees with AI skills and more than half of these companies have only five or fewer AI talents, indicating that their scale is still small. Approximately, AI specialists occupy 2.7% of the total number of employees.

Noteworthily, Fig. 1 has illustrated that 65.8% of the firms have applied AI technologies. However, only 27.7% of them have employees with AI skills. The gap between the two suggests that some firms' AI applications were developed by outside or contracted sources instead of in-house teams. Or they used existing manpower in the early trial and error stage without hiring or distinguishing AI specialists.

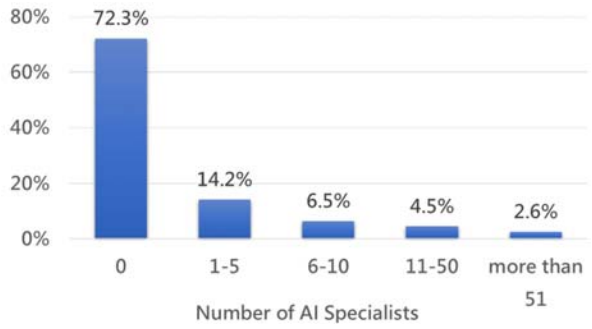


Fig. 2 Distribution of AI specialists in the High-tech Manufacturing Industry

### *C. Five Key AI Job Vacancies in Taiwan's High-Tech Manufacturing Industry*

This study gathers information from sources like expert opinions, industry reports, job vacancies and conferences in recent years to understand the nature and division of work among AI specialists and then identify five key job vacancies and their structures based on job description, as shown in Table I and Fig. 3.

TABLE I
Five Key Job Vacancies Description

| Key Job Vacancies | Job Description |
|---|---|
| AI Application Engineer | In charge of the creation of AI-related products. Apart from general programming skills, they also have AI application knowledge and integrated capabilities of developing AI programs, algorithms or systems. In addition, the design and development of AI hardware equipment, such as hardware circuit design and image recognition system development, are included. An AI software engineer and a machine learning engineer fall into this category. |
| Field Application Engineer | Specialized in providing technical solutions and services to clients, including feasibility assessment, product installation and troubleshooting, after-sales service, and technical support to clients, other departments or sites. Also called "customer service engineer". |
| Data Engineer | In charge of converting raw data into formats needed for analysis. Familiar with the system structure of data storage environment and ETL (Extract-Transform-Load). Help collect, categorize and process information. |
| AI and Data Scientist | Build statistical analysis models or algorithms in response to business needs or commercial issues. Provide results of prediction analysis and solutions as references for decision making and implementation. An algorithm engineer falls into this category. |
| AI Project Manager | Assist with the internal and external communication of project teams, schedule planning and budget control. Familiar with the basic knowledge of AI applications. Apart from conducting demand interviews and coordinating projects, they are often required to have basic data analysis and data visualization skills. |

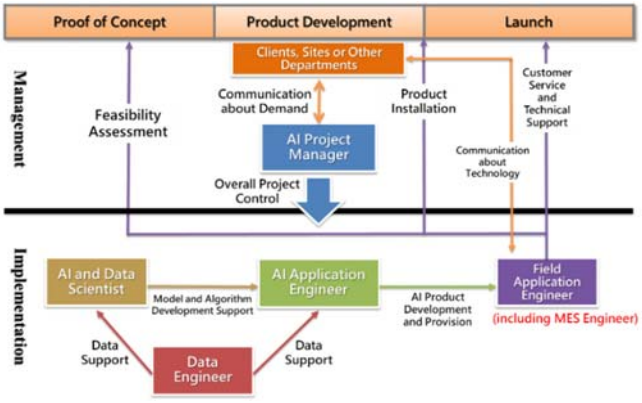


Fig. 3 Structure of Key AI Job Vacancies in the High-tech Manufacturing Industry

## IV. Comparisons of Demand for AI by Sub-Industries

The high-tech manufacturing firms investigated in this study fall into two major categories: "Electronic Parts and Components Manufacturing" and "Computers, Electronic and Optical Products Manufacturing". Due to differences in their nature, the two differ from each other in AI applications, talent demand and organizational training.

### *A. Comparisons of AI Applications Areas*

In the Electronic Parts and Components Manufacturing Industry, semiconductor companies' AI applications focus on technologies used in their own product lines with the aims of improving the yield and lowering the cost; the Computers, Electronic and Optical Products Manufacturing Industry's AI applications are more diverse in application areas and product usage. Some of the firms tend to focus more on hardware and look at what hardware products they already have as a starting point to create a synergy with AI applications. Many of the Computers, Electronic and Optical Products Manufacturing firms investigated have invested in the medical care AI applications, followed by smart retail.

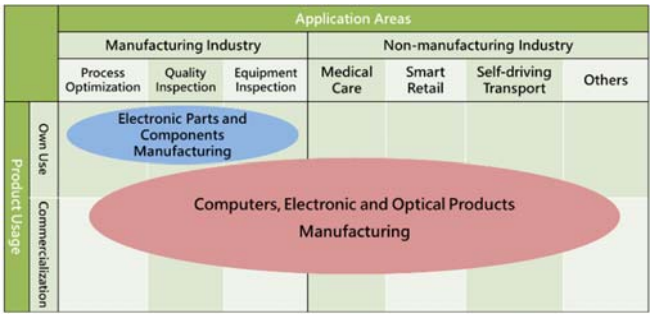


Fig. 4 AI Application Areas and Product Usage by High-tech Manufacturing Sub-industries

Regarding the differences in AI technologies used, the Electronic Parts and Components Manufacturing industry places more emphasis on process optimization. Therefore, data analysis and inference and data capture and cleaning technologies are most used—in 20.9% and 14.5% of the firms respectively. In contrast, both of the two types of technologies are most used in only 4.4% of the Computers, Electronic and Optical Products Manufacturing firms; the industry faces more demand for end product assembly service and for this reason depends more on motion control technology, such as robotic arms, occupying as high as 20% of technologies used. In the case of the Electronic Parts and Components Manufacturing industry, motion control technology is most used in only 6.4% of the firms.

TABLE II
Differences in AI Technologies Used by High-tech Manufacturing Sub-industries

| Most Used AI Technologies by Firms | Computer Vision | Data Analysis and Inference | Motion Control | Data Capture and Cleaning | Natural Language Processing | No or Under Development |
|---|---|---|---|---|---|---|
| Electronic Parts and Components Manufacturing | 24.5% | 20.9% | 6.4% | 14.5% | 0.9% | 32.7% |
| Computers, Electronic and Optical Products Manufacturing | 28.9% | 4.4% | 20.0% | 4.4% | 4.4% | 37.8% |

### *B. Comparisons of AI Talent Demand and Training Models*

The differences in AI technologies and applications between the two sub-industries also lead to their differences in talent demand. Looking at the structure of five key job vacancies, the Electronic Parts and Components Manufacturing industry has a higher percentage of data engineers than the Computers, Electronic and Optical Products Manufacturing industry. The reason is that process optimization requires more data processing work, while the Computers, Electronic and Optical Products Manufacturing industry has a higher percentage of AI and data scientists due to its higher percentage of diverse non-manufacturing AI applications and thus greater demand for the development of new algorithms.

At the organizational level, depending on their nature and structure, different companies use different approaches to create a synergy between newly hired AI specialists and existing employees. There are three main models: centralized, distributed and hybrid.

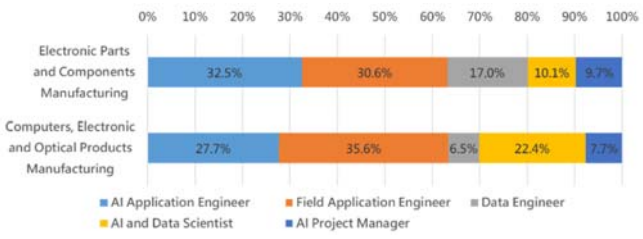


Fig. 5 Percentages of Current Key AI Job Vacancies by High-tech Manufacturing Sub-industries

Generally speaking, most companies tend to hire a small number of AI specialists or experts at the early stage, and then

gradually increase the number to build a centralized system, which means putting most of the AI talents in one specialized AI application department or research center, including AI application engineers, data engineers, AI and data scientists and AI project managers, while FAEs experienced in field application are distributed across business units in the organization as well as the AI application research center to help implement projects.

In other cases, if business units in a company have more independence, they may establish their own AI departments that begin to develop as distributed organizations with AI talents distributed in each business unit. These distributed organizations can also be formed by the decentralization of the centralized system. If only part of the staff is scattered and the centralized organizations remain then it is possible that the two models coexist. That is to say, AI talents can be found in both specialized AI department and other small units. If necessary, AI specialists may engage in job rotation or task force activities.

In terms of AI talent organizing and training methods, this study finds that the structure of the Electronic Parts and Components Manufacturing industry is more centralized while the Computers, Electronic and Optical Products Manufacturing industry tends to be more distributed. In terms of training methods, the Electronic Parts and Components Manufacturing industry mainly uses the elite system while the Computers, Electronic and Optical Products Manufacturing firms that adopt the general education system are trying to integrate AI applications and hardware products.

In Fig. 6, (a) "Centralized" means a company's AI talents are centralized in a specialized AI application department or research center. (b) "Hybrid" means a company places its AI talents in both a specialized AI department and other small units. Job rotation or task force activities are possible. (c) "Distributed" means AI talents distributed across business units. (d) "Elite System" focuses training resources on a small number of selected employees. (e) "Elite System + General Education" means training a small number of selected employees and at the same time offering general education to a large number of employees, may select employees suitable for further training through general education. (f) "General Education" offers general AI education to all or a large number of unselected employees.

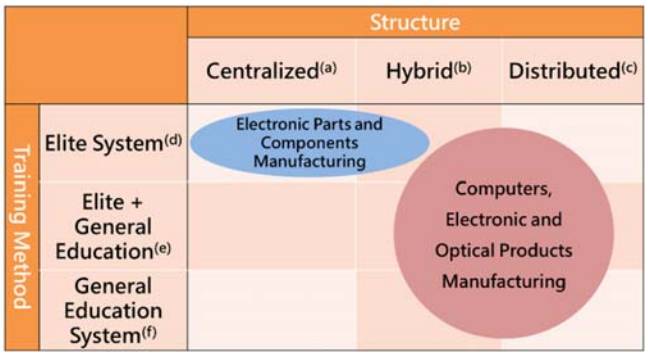


Fig. 6 AI Talent Organizing and Training Models by High-tech Manufacturing Sub-industries

## V. Conclusion

This study investigates the mainstream AI technology applications, talent structure, training methods and differences between sub-industries in Taiwan's high-tech manufacturing industry with the attempt to reflect its real situation of AI applications through a comprehensive analysis.

AI application and development still has promising prospects in the manufacturing industry, expected to solve many problems that cannot be solved by traditional manufacturing or management approaches and significantly reduce operating costs. However, modern manufacturing industry is highly professional and complex, requiring more customized AI applications. One solution may not work for all and can only be duplicated for the same type of application in similar sites. As a result, AI commercialization in the manufacturing industry is still not common.

For the manufacturing industry, the obstacles of AI commercialization will lead to higher investment costs. If there are not enough benefits or incentive, smaller scale enterprises may rely on outside or contracted sources to build AI applications. To solve the root problem of AI commercialization, it is necessary to innovate and develop algorithms. Therefore, AI and data scientists in charge of developing algorithms have become pivotal in this process.

## Acknowledgment

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