Teaching Plan

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July 22, 2024

1 Vision: Training World-leading Next Generations

In this teaching statement, I explain the mindset I pursued during my Ph.D., the attitudes and experiences I wish to pass on to the next generation, and the reasons behind these intentions. First, let me start by summarizing my experiences to explain why I want to leave the industry and return to academia to cultivate world-class next generations. **Phase 1 (2017–2022).** During my Ph.D., I proposed a pioneering and state-of-the-art LiDAR place recognition method (with more than 750 citations to date, IROS 2018 and T-RO 2022) and integrated it into a complete LiDAR Simultaneous Localization and Mapping (SLAM) system. By releasing this as open source, I contributed to helping researchers and practitioners save time, reconstruct their spatial environments more easily, and make robot navigation effective. In doing so, I published a series of related works that continuously persuaded academia about the problems I solved for LiDAR SLAM, the problems I haven't solved, and the issues that still remain to be addressed. **Phase 2 (2022–2024).** During this period, I had also been participated as the main researcher for two and a half years in a project with NAVER LABS, with which I am currently associated. Therefore, I believed, at that time, I am the right person to solve the issues they face regarding SLAM and real-time localization in complex urban areas, as I have been able to deeply understand and analyze their problems over the years. Currently, I have been contributing to this effort for two and a half years, and I received the highest performance rating for two consecutive years.

Phase 3 (now). However, through my experience in the corporate world, I realized that although I contributed to the company's product by solving problems that others could not, it was clear that the structure of industry made it difficult to have a *combinatorial* impact on society, particularly on the younger generations. Specifically, there are two goals I wish to achieve through teaching at DGIST.

Phase 3-1, training world-leading researchers for academia (Sec. 2.1). In Korea, as the birth rate continues to decline, it is expected that the number of new generations will decrease. I believe that the only way to address this issue is by nurturing world-class talent. Even if I develop world-class SLAM technology within one company, it does not spread quickly or get easily replicated (so I would like to say its impact upper bound is sublinear). On the other hand, if I deliver my mindset and experiences to 10 students, they can innovate within 10 different companies or 10 different interdisciplinary sectors. If each of them, in turn, passes this knowledge on to 10 others, we can achieve an $O(n^2)$ or higher rate spread of this mindset (I want to call it combinatorial impact). It is particularly important to foster a mindset and to have actual experience in leading world-class research in Korea. Therefore, my primary teaching objective is to guide students to that level step-by-step and offer them a structured personal training course to accomplish this. Further details can be found in Sec. 2.1.

Teaching Statement 1. To train world-class robotics researchers who not only possess a world-leading mindset but also have experience in pioneering world-class research topics. By doing so, elevate DGIST's Department of Robotics and Mechatronics Engineering to a world-renowned status.

Phase 3-2, training pragmatic engineers for industry (Sec. 2.2). Especially in the first half of 2024, the thought (i.e., non-combinatorial impact generation within a company) was further reinforced as I participated as the NAVER LABS's interviewer in numerous job interviews for doctoral-level new employees and master's/bachelor's level research interns. Here is what I felt. Over the past five years, with the boom in AI and deep learning, and the availability of easier tools, there have been many students familiar with deep learning. However, I noticed that there are not many graduate students equipped with the experience needed to meet the demands of actual robotics companies (e.g., experiences handling sensors at a system level, understanding of coordinates, overlapped region of dynamics and computer vision, hard real-time programming, numerical optimizations, etc). This is not the students' fault. They are aware of their lack of practical robotics skills and proactively seek opportunities, such as internships at NAVER LABS, to build these skills. However, since the number of internship slots is limited and

the company's objectives are not fully aligned with nurturing future generations, I was disappointed that I could not inspire and help all the applicants. Therefore, I would like to influence more students in academia and in DGIST, and guide them to develop the suitable skills they need in the industry. In particular, I believe that students who graduate with an M.S./Ph.D. from a research-focused institute like DGIST and contribute to the industry should not only be engineers but also act as industry leaders.

Teaching Statement 2. To train industry leaders who not only have a solid understanding of theoretical history but also have experience in solving real-world problems, possess distinctive troubleshooting skills, and have the confidence to tackle future challenges based on their own fruitful experiences. By doing so, elevate South Korea's robot industry competitiveness.

I plan to pursue these two primary visions in my teaching (i.e., TS. 1 and TS. 2). The first is to contribute to academia, and the second is to contribute to industry. The third goal is to maintain a balance between the two and to produce world-class talents with capabilities in both areas, thereby contributing to DGIST, the nation, and the global robotics scene. In the next section, I cover the details of my teaching philosophy to meet the visions.

2 Teaching Philosophy: Two Big Goals

2.1 Training World-leading Researchers

As I have completed my Ph.D. and made a continuous impact on academia, I realized this following finding. To be in the top 1% of researchers leading the field, not just the top 10%, and to conduct pioneering research, the mindset is even more important than technical skills or GPAs. I believe that to lead the global robotics scene in academia, one must possess the following three philosophies. I will put in significant effort to directly transfer these philosophies to my lab and the department students.

Philosophy 1: Problem Ownership and Leadership. *Problem Ownership* is the result of answering the following questions: Where does novelty in academia come from? As a researcher from South Korea, which has a relatively small pool of researchers, how can we make a significant impact on the world and even lead them? What must we do to achieve this? There are two types of *novelty*: **1. problem novelty** and **2. method novelty**. I have learned that the former (problem novelty) could have a broader and more significant impact. Research is not a competition; it is a cyclical process of advancing the world by helping each other. In this process, who will willingly take on the role of a leader, even in a small field? It does not matter if they could not solve all the problems in that field. Instead, they are someone who is incredibly eager and passionate about solving those problems. They must be someone who believes that solving this problem is very important, more than anyone else in the world. They are also someone who is ready to share all their prior research results and knowhows with subsequent researchers. These people should also prepare appropriate evaluation datasets and provide baseline methods for others to build upon. Through this process, they make a **continuous contribution** (will be introduced in the below Philosophy 3) to academia and ultimately expand the scope and the size of a pie of their field. Thus, I would define the term problem ownership and the leadership like:

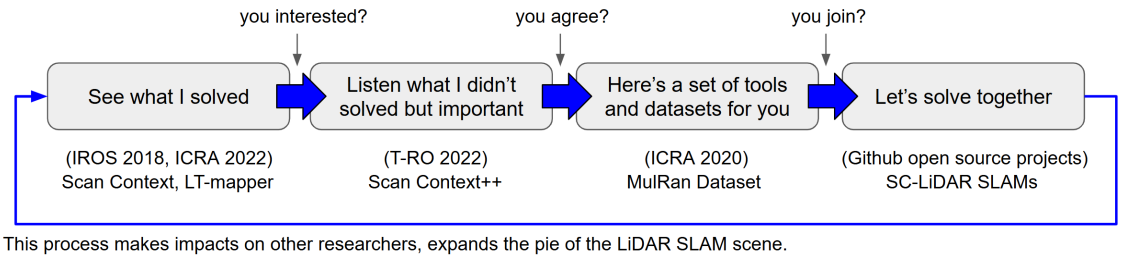


Figure 1: A visual example of Def. 2. A cycle of continuous conversation with academia as a problem owner. This visualizes the iterative process of the cooperative development cycle while having problem ownership and leadership. The papers are IROS 2018 [1], ICRA 2020 [2], ICRA 2022 [3], and T-RO 2022 [4], respectively.

Definition 1. *Problem ownership* means having the mindset that solving this problem is crucial, believing this more strongly than anyone else in the world, and being the first to take action.

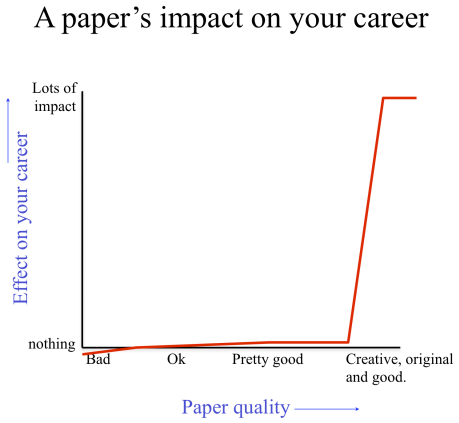
Definition 2. *Problem leadership* refers to the willingness to undertake a series of activities to gather, encourage, and assist peers after embracing the problem ownership, despite of the process might be potentially tedious. It ultimately means triggering them to drive explosive growth in the field, together.

Visualizing the problem ownership and the problem leadership can be seen in Fig. 1. This represents the ability to gather colleagues. It means acknowledging humbly that I cannot solve all problems on my own, yet still having the confidence to lead and the determination to achieve success. This is a cycle. My first goal is to teach students who possess these mindsets to make continuous contributions to academia.

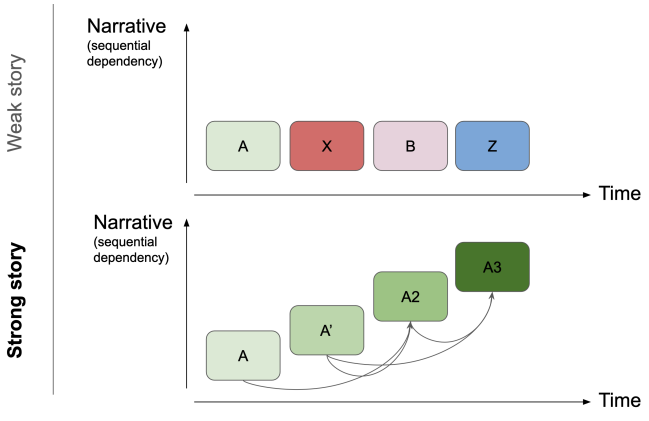
Philosophy 2: Impact-driven Research. There is something called the Pareto Principle, also well-known as the 80-20 rule. When applied to research, it can be stated as follows: 80 percent of the outcomes come from 20% of the papers. This is why a plot like the one in Fig. 2a is popular on the web (source[1]). This is not just a matter of being evaluated based on quantitative achievements (e.g., citations). For more important reason is that contributing to Philosophy 1 mentioned earlier. To do so, 'impact' must be fulfilled. It is not about conducting the 20% of impactful research just to get more citations. Rather, if the research is not impactful, it cannot contribute to Philosophy 1. Therefore, I define the concept of impact as 'a state where the academic community cannot revert to the time before the paper was published.

Definition 3. An *impact* is defined as occurring when a paper has an irreversible influence on researchers and practitioners who read it or use its methods, preventing them from reverting to previous approaches, or when it directly leads to the appearance of such *impactful* papers.

Therefore, I emphasize here that each Philosophy is not independent but a complementary combination that must be fulfilled for each other.



(a) A famous visualization figure on the web regarding the impact.



(b) The structure of a strong story of a Ph.D. thesis.

Figure 2: (a) A visual definition of Def. 3. To create an impact, just being okay is not enough. It is needed to surpass some discrete threshold. (b) A visual definition of Def. 4. Unlike a career where less related (the upper one), a research career like the one below, where the works are interconnected and contribute to the subsequent work, can surpass the threshold to create impact through continuous contributions.

Philosophy 3: Continuous Contributions. To become a world-leading researcher, an extended understanding of a term 'contribution' is required. Beyond simply having a set of contribution from a single paper, it is

[1] https://www.cs.jhu.edu/~cxliu/2020/key-lessons-for-a-successful-phd-career.html

important to contribute successively at different levels and purposes throughout the entire research cycle, as shown earlier in Fig. 1. I call this 'continuous contributions' (see Fig. 2b).

Definition 4. Continuous contributions mean planning and conducting a series of related studies with problem ownership. By building a narrative with sequential dependency, impact can be achieved.

2.2 Training Pragmatic Engineers

Just like any engineering field, robotics should not just stay theoretical. Right now, it looks like the robotics industry is about to boom with huge demand and supply. But from my experience in the industry, I have noticed that there are still not enough engineers who really know robotics and are skilled in both hardware and software, as well as programming, to meet that demand. Also, in a quantitative aspect, the number of graduates would be working in the industry is basically higher than those becoming academic leaders, such as professors or researchers at government-funded institutions. Therefore, my second teaching goal is to cultivate 'industry leaders' who can make important decisions in various robotics companies. Industry leaders do not compromise on standards. In fact, in some ways, they would have even higher standards and goals than researchers in academia.

3 My Strengths for Teaching

For undergraduate students: Wandering experience during B.S.. I graduated with a B.S. degree in Civil and Environmental Engineering, not robotics. Starting from my senior year, I began taking courses in Electrical and Electronic Engineering and Computer Science, and in graduate school, I finally came to be possible to be majoring in Robotics. In short, I have gone through my own iterative trial and error process to find my strengths and fit major. Therefore, beyond simply teaching subjects, I understand the concerns of young students and give them advises while they are seeking their strengths and majors as well as having inevitable mistakes.

For graduate students: Problem owning and leading experience and resulting mind. I had a series of experiences of having pioneered the field of LiDAR place recognition with a strong sense of problem ownership, as shown in Fig. 1. I also expanded the pie and influenced subsequent papers of academia. Therefore, I can share not just superficial advice but stories from my experience about the importance of the three philosophical approaches mentioned earlier with students aspiring to become world-leading researchers. This will help them make the right decisions during their career stages. Because an impactful paper requires both timing and patience.

For students who want to be engineering leaders: Industry experiences. Given the characteristics of the field of robotics and the current demands of the world, I think students majoring in robotics are more likely to contribute to the industry rather than academia. However, to create a global impact at a research-focused university, DGIST, we must conduct zero-to-one research. Therefore, students may sometimes feel that these two goals conflict. I had such a similar experience and feeling. To balance both, I believe that having up-to-date industry experience is crucial. Thus, I spent nearly three years at NAVER LABS solving real-world problems, from autonomous vehicle to street-view vehicle-based digital twin generation. I will guide students to understand that these two goals are not a matter of choice but are complementary. This will help them develop not only their research skills but also their capabilities as pragmatic engineer. By doing so, I will assist the younger generations in resolving their concerns.

For talented but freshman-level students. I have experience working as a lecturer at the KAIST Global Institute of Talented Education from 2014 to 2017. In this role, I was responsible for a class of selected teenagers who were interested in mathematics and science for one year. Each class consisted of 10–12 students, and for a year, I interacted and empathized with them not just as a teacher but more like a homeroom teacher. I led a total of four classes for four years, fostering scientific talents. I planned 10 sessions per semester, with each session consisting of 3 hours of theory and practice. Classes were held every Saturday morning, and I genuinely wanted the students to enjoy their time. I was very happy when they told me they looked forward to Saturdays. Through this experience, I am confident that I can coordinate and adjust the level of a lecture for teenagers and freshmen of DGIST, and effectively awaken their pure enthusiasm for science, engineering, and programming.

For the first-step into academia of younger next generations. During Ph.D., in the laboratory, I assisted my lab friends in publishing their first flagship conference paper, helping them gain confidence (RA-L 2022, IROS 2022). Additionally, at NAVER LABS, I supervised a research intern who graduated with a master's degree from

DGIST, resulting in the publication of a paper at ICRA 2024, and currently, we are in revision of a paper for RA-L. I am very interested in how the next generation of researchers can develop their own confidence when their first journey start. It involves demanding a high standard from them while making them believe that they can achieve that level. The younger students in the next generation seem to already have a solid technical foundations. However, they need guidance on overcoming challenges, knowing what to do or not, at a proper timing. I have also been a reviewer for flagship conferences and journals such as IROS, ICRA, RA-L, T-RO, and T-ASE, and am well familiar with the standards at each stage. Additionally, in recent years, I have served as an Associate Editor (AE) for UR (International Conference on Ubiquitous Robots) for three years, gaining deeper insights into the review process from a judge's perspective. Through these experiences, I can guide students to minimize technical errors and enhance their paper-writing activities.

References

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