# Cross research lab and student research projects

The Cross lab in the Tokyo Tech School of Environment and Society, Transdisciplinary Science and Engineering department does research in three research areas: Biofuels, Japan's energy policy and Artificial Intelligence (AI) in Education (formerly called educational technology). In addition, Asst. Prof. Cheng Shuo is undertaking research on Uptake and Effects of Microfibers on Freshwater Indoor Microcosm Systems and leads the Environmental Toxicology Research activity.
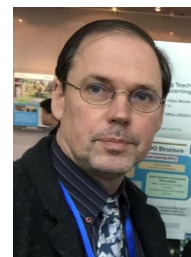
Currently, there are 15 doctoral(D), master(M) and 4th year undergraduate students (B4) conducting research to meet their graduation degree requirements supervised by Asst. Prof Shou Cheng and Prof. Jeffrey Cross. Graduate students are affiliated with 1) Energy Science and Engineering, 2) Global Engineering for Development, Environment and Society (GEDES) or 3) Materials Science and Engineering graduate majors. Graduate students are admitted either into the Japanese language degree program or international graduate program (IGP C – no scholarship, A – with or without MEXT scholarship) or as working doctoral adults where courses are taught in English. The lab is very diverse with students from 11 different countries (Canada, Cambodia, China, France, Indonesia, Japan Mexico, Mongolia, Philippines, Pakistan and USA). Student's academic backgrounds are varied as well with prior degrees in Chemistry, Chemical Engineering, Engineering Science, Computer Science, Mathematics, Mechanical Engineering, Physics, Energy Economics, Educational Technology and Literature (liberal arts). Students attend weekly seminars in their research groups to present current research paper or research progress reports. Education in the lab is very interdisciplinary, which is very unique at Tokyo Tech due to students' various educational backgrounds and research interests. Below is a photo from a laboratory seminar.

In addition, Prof. Cross also manages the Tokyo Tech online education development office, which is responsible for developing online courses and is also active in learning analytics research related to online course quality assessment. Please contact Prof. Cross by email if interested in visiting, joining the lab or request more information related to on-going research projects.
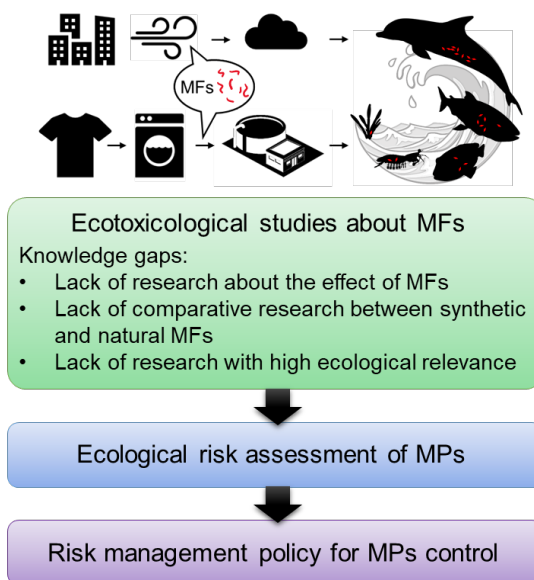
Jeffrey S. Cross

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https://jscross18.wixsite.com/crosslab

November 2020 Cross lab about

<mark>Environmental Toxicology Group:</mark> Uptake and Effects of Microfibers on Freshwater Indoor Microcosm System

マイクロ繊維の取り込みと淡水コズム生態系への影響

Abstract

Microplastics (MPs) in the water body are novel pollutants that attracted attention in the scientific community in recent years. Microfibers (MFs), as one of the most common MPs, distribute highly overlaps with the dense population areas and pose a threat to biota, especially to humans. There are still several knowledge gaps on MFs so far, such as the lack of comparative studies with natural fibers or ecotoxicological data above the organism level, making it hardly possible to make a conclusive assessment ecological risk for MP up to now. This research proposes to conduct synthetic and natural MFs exposure experiments in a freshwater indoor microcosm with a three-species food chain. We will evaluate the effects of MFs on the microcosm from molecular to community level. The results can provide the necessary data for ecological risk assessment and help raise public risk perception of MFs. Eventually, contribute to the formulation of risk management policies for MPs.

Ecotoxicological studies about MFs
Knowledge gaps:
- Lack of research about the effect of MFs
- Lack of comparative research between synthetic and natural MFs
- Lack of research with high ecological relevance

Ecological risk assessment of MPs

Risk management policy for MPs control

Methodology

This research proposes to conduct synthetic, plant, and mineral MFs exposure experiments in a freshwater indoor microcosmic system with three trophic levels of the food chain (producer, first-level consumer, and second-level consumer). The stress response and adaptation of three model species on introduced MFs will be evaluated from molecule to community level under controlled biotic and abiotic conditions. Combining multivariate and statistical analysis methods, qualitative and quantitative analysis of the comprehensive effect of different materials and different concentrations of MFs on the microcosm will be carried out. We want to figure out:

a. Does MFs provide special effects on the biota due to their fibrous shape?

b. Compared with the natural MFs, what is the difference in the effects of synthetic MFs on the biota?

c. To obtain data with higher ecological relevance than previous studies that on each species separately.

It is possible to build a bridge between the laboratory and the ecosystem, which helps confirm extrapolations from laboratory data to the environment. The research results can provide the necessary information and data for the ecological risk assessment of MFs in the water body. It will help raise public risk perception to MFs, which has so far been neglected. Eventually, contribute to the formulation of risk management policies for MPs.
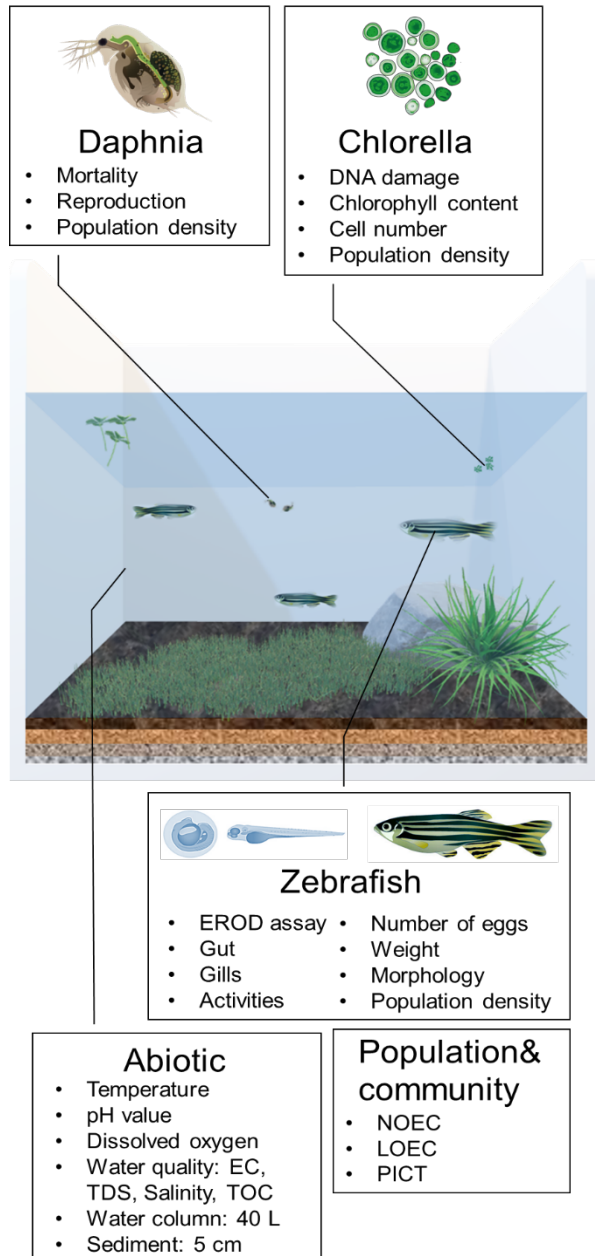
If you are interested in these topics please contact Asst. Prof. Cheng for further information and if interested apply for admission in order to join us!

Daphnia
- Mortality
- Reproduction
- Population density

Chlorella
- DNA damage
- Chlorophyll content
- Cell number
- Population density

Zebrafish
- EROD assay
- Gut
- Gills
- Activities
- Number of eggs
- Weight
- Morphology
- Population density

Abiotic
- Temperature
- pH value
- Dissolved oxygen
- Water quality: EC, TDS, Salinity, TOC
- Water column: 40 L
- Sediment: 5 cm

Population& community
- NOEC
- LOEC
- PICT

Building Research Self-Efficacy of Cambodian Undergraduate Students through Mixed Information and Communication Technology Training

Seng Cheyvuth GEDES D3, IGP-C, (JICA Scholarship)

The Cambodian higher education sector has experienced a resurgence after the civil war (lasting from 1975 till 1979). However, there were no established official policies related to research promotion within a thirty (30) year (1979 to 2009) period since Higher Education Institutions (HEI) were re-established. The object of the study is designed according to the four main objectives of this study, namely: i) to assess the needs for ICT adoption and MOOC of Cambodian graduate students; ii) to examine the competency of Cambodian graduate students in applying ICT skills in research activities; iii) to identify the relationship between the adopted and trained ICT skills and their research competency and research intention; and, iv) to examine the different effects of the three sets of ICT skills (1. Data analytics software, 2. Reference and office software, and 3. MOOC) on research competency and research intention. The purpose of this research is to contribute to the existing knowledge regarding the use of ICT skills by training, to increase research productivity in higher education institutions in Cambodian (See Fig 1-3). Furthermore, this study will be a necessary tool in research and it will allow researchers to make informed decisions regarding low and heavily skewed research productivity in academics.

All educational research activity is conducted in the Khmer language including surveys and interviews. The results have been summarized in 3 papers submitted for publication in 2019.

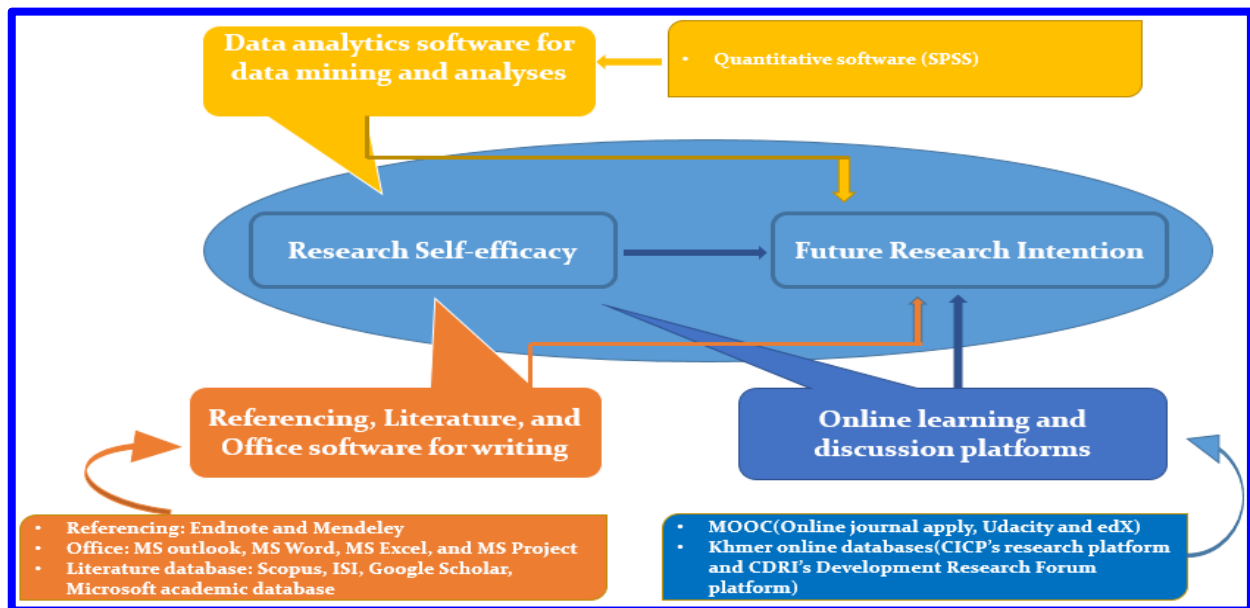**Figure 1. Map of ASEAN Counties and map of Cambodia**

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Figure 2.   Conceptual Framework for self-efficacy

Figure 3.   Research Activity in Cambodia at a Provincial University

Uptake and Effects of Microplastic Fibers and Fragments on Seawater Commercial Bivalves (Oyster and Scallop)

Jessica, GEDES, M1, IGP-C, (Asian Development Bank (ADB) Scholarship)

In 2018, global plastic production has almost reached 360 million tons and approximately 8 million metric tons of plastic enters the ocean annually. Petroleum-based plastics do not biodegrade; they will break down into smaller pieces over time into microplastics. In the ocean water column, microplastics are mostly found in fiber shape and fragments with a concentration of 52% and 29% respectively. In terms of polymer type, the greatest proportion found was polypropylene (PP) with 17% followed by polyethylene (PE) and polyethylene terephthalate (PET) with 15% each. The presence of these microplastics in the ocean poses risks to marine biota as they are ingested by various marine organisms. Due to their high surface area to volume ratio, microplastics are able to adsorb hydrophobic contaminants such as Persistent Organic Pollutants (POPs) which may increase their toxicity when ingested. Based on the fishery production statistic survey in Japan, oysters and scallops are the two most produced bivalves. They both are susceptible to microplastics exposure from the water column and sediment. This research aims to study the effects of microplastic ingestion by bivalves. PP and PET with benzo(a)pyrene (BaP) are used to represent plastics and POPs in the ocean. Exposure of plastics are carried out in the form of microplastic fragment and fiber to find the type and shape preferred by the bivalves during ingestion. Qualitative and quantitative analysis is carried out by using laser scanning confocal microscope (Fig. 1). Subsequently, the most ingested plastic will be spiked with BaP to observe the transfer of contaminant into the oysters and scallops. Toxicological analysis will be performed to determine the systematic effects in the bivalves.
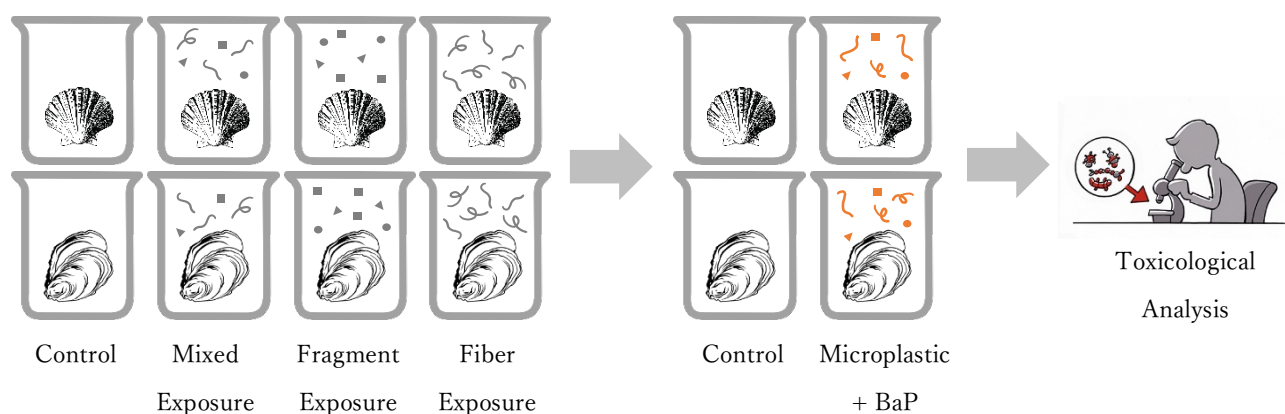

Fig 1. Proposed method to observe the effect of microplastics in oyster and scallops

Personalized Online Adaptive Learning System

May Carlon, GEDES, D3, IGP-C (Tokyo Tech Tsubame Scholarship)

Metacognition, or the knowledge and regulation of one's thinking process, includes skills such as goal-setting and knowledge monitoring, among others. Multiple research studies have shown that metacognition contributes to learners' academic performance and improves their growth mindset. However, creating a tutoring system that effectively teaches metacognitive skills and evaluates its effectiveness is challenging. Training for metacognition, a domain-independent skill, usually involves learning a domain-specific skill (e.g., mathematics, language, and others) alongside, thus putting a strain on the learners' cognitive resources. One way to manage cognitive resources while using tutoring systems is through applying educational technologies that adapt the learning path based on the learners' characteristics. In this research, we will use prompts to help learners develop metacognitive skills along with adaptive learning for the domain-specific instructional materials to lessen fatigue while still ensuring mastery. We will also be using natural language processing and machine learning techniques to get course quality feedback from the learners' interaction with our tutoring system, see fig below.
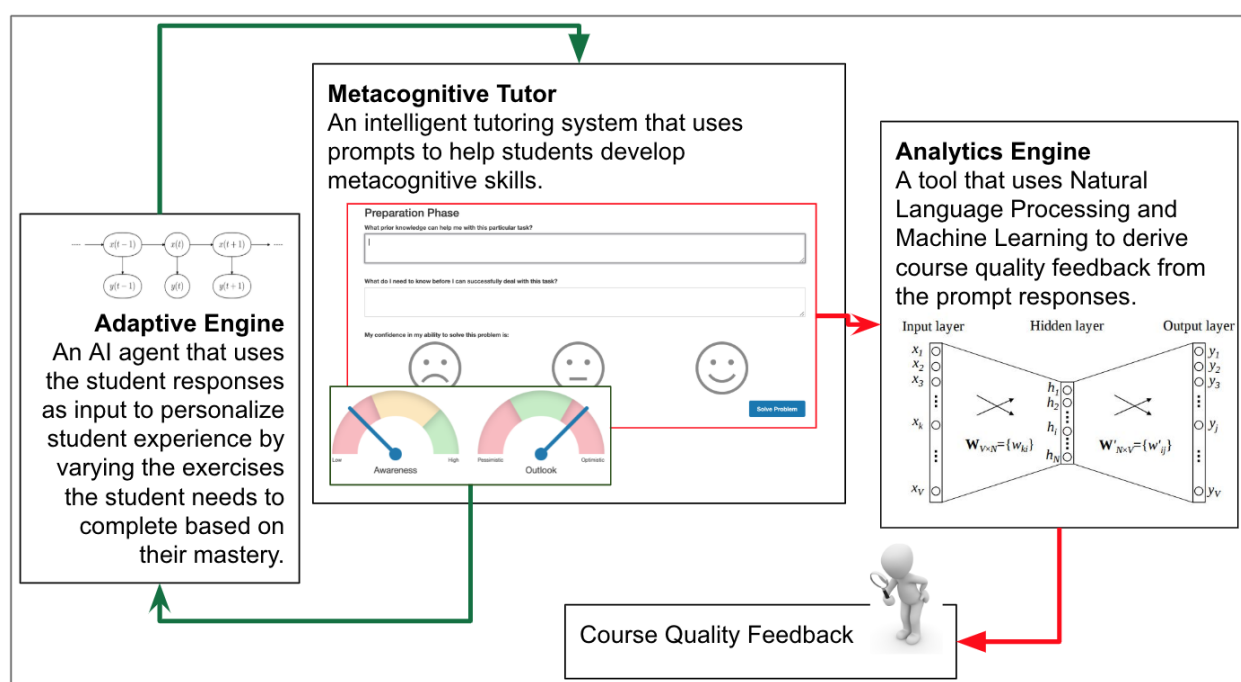

Personalized Online Adaptive Learning System Overview

Promoting Students and Teachers to Become Lifelong Learners through Play

Luc Gougeon, GEDES D3, IGP-C

In 2020, Japanese primary school educators will face the difficult challenge of introducing programming in their classes despite the fact that they never studied programming themselves. Our research aims are mapping the specific contours of the knowledge gap in-service teachers and extend this surveying to current universities students who are also lacking computer literacy skills. Most research in the field of computer literacy places a strong emphasis on children while neglecting the needs of in-service educators and older students. We will tackle this research by both surveying a range of students and teachers while conducting case studies consisting of an education intervention meant to give university students a quick grasp of computational thinking, computer literacy and basic programming concepts. The case study approach intends to offer students essentials skills in an active learning environment, skills which will be transferable to their future workplace or classroom if they intend to become educators. The results of this study are intended to offer stake holders and policy-makers a clearer picture of the current educational landscape and enlighten their decisions. Below is an illustration of summarizing the issues which will be investigated related to education approaches and students' knowledge needs.

November 2020 Cross lab about
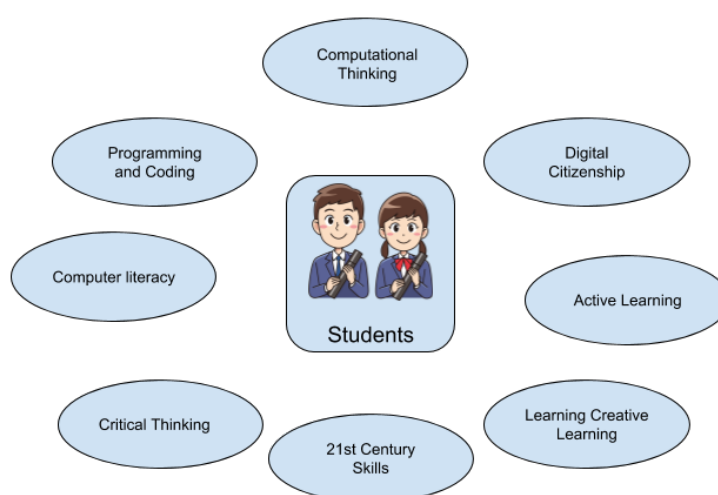
A chatbot for a TSE professor's laboratory using combined architecture

B. Dorjzodovsuren, TSE dept., GSEP B4 student (MEXT scholarship)

One of the big issues in the educating process is reaching out to every student individually and providing them with the information they need to take control of their learning. Chatbots are gaining popularity as means of providing information by using Artificial Intelligence (AI), which has become popular. A Chatbot has tremendous potential by simulating an intelligent conversation with students, who are making an inquiry. In the context of learning process, chatbot can create a learning experience similar to one-on-one instruction. Using chatbots as a teaching resource offers the opportunity to increase instructional services to serve a wide range of students and reduce burden on staff and faculty from answering routine queries. If a bot can provide the teacher with support and answer students' questions in the lab, the teacher can focus more time on teaching and research. When a new undergraduate or graduate students joins a lab, they need to understand the lab operating principles or guidelines and also safety procedures when they are doing lab work. After reading the laboratory guideline, it is quite frequent that students cannot remember some information. Searching for information from the lab guideline is time consuming in order to find their required information. Instead of reading through the whole guideline, which is 15 pages to find relevant information, interactively asking the chatbot questions to find the information is easy and takes less time to find required information (hopefully). The expected outcome of this research project is to create a chatbot that uses both a rule-based and deep learning architectures for retrieving information from the Cross' laboratory guideline.
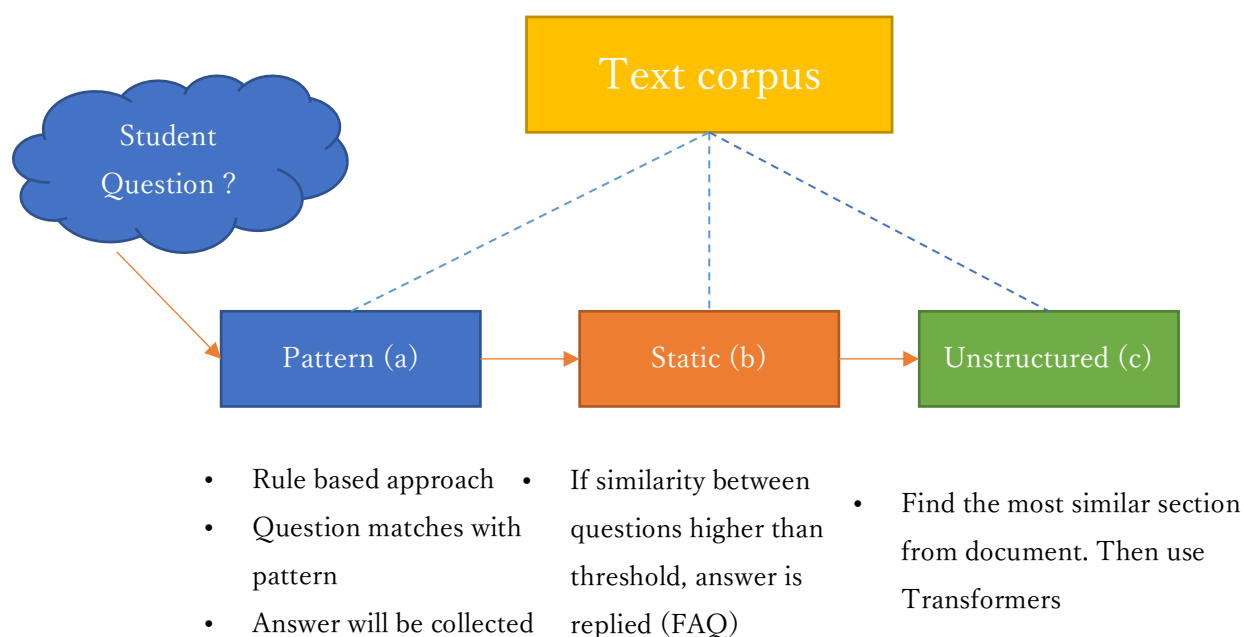

Figure 1 : Chatbot Workflow for retrieving information from the lab guide

November 2020 Cross lab about

AI-based writing assistants' impact on English language learners' writing fluency

John Maurice Gayed, GEDES D1 student, Working-Adult Doctoral Program

Gayed is a first-year American working adult doctoral student. He is interested in computer assisted language learning, learning management systems, information literacy and digital learning. Gayed is tech enthusiast and full-time university lecturer teaching English for Academic Purposes among other courses at the University of Hyogo's School of Engineering, Himeji, Japan.

Gayed is currently researching the potential to use an AI-based writing assistant for second language learners at Cross lab.

Figure 1 Sentence fragment with predicted word use

Little research has been done on how these systems affect L2 writing output and the researcher believes these systems will be as prevalent as spell-checking/grammar checking systems that were first developed more than thirty years ago. He plans to develop these tools to assist Japanese university students who are enrolled in English for Academic Purposes (EAP) courses overcome the various cognitive barriers they face when they attempt to produce written text in English. The researcher is developing the AI system based on Open AI's GPT-2 language model. The expected outcome of the research is that AI-based writing assistants can improve students' writing fluency.
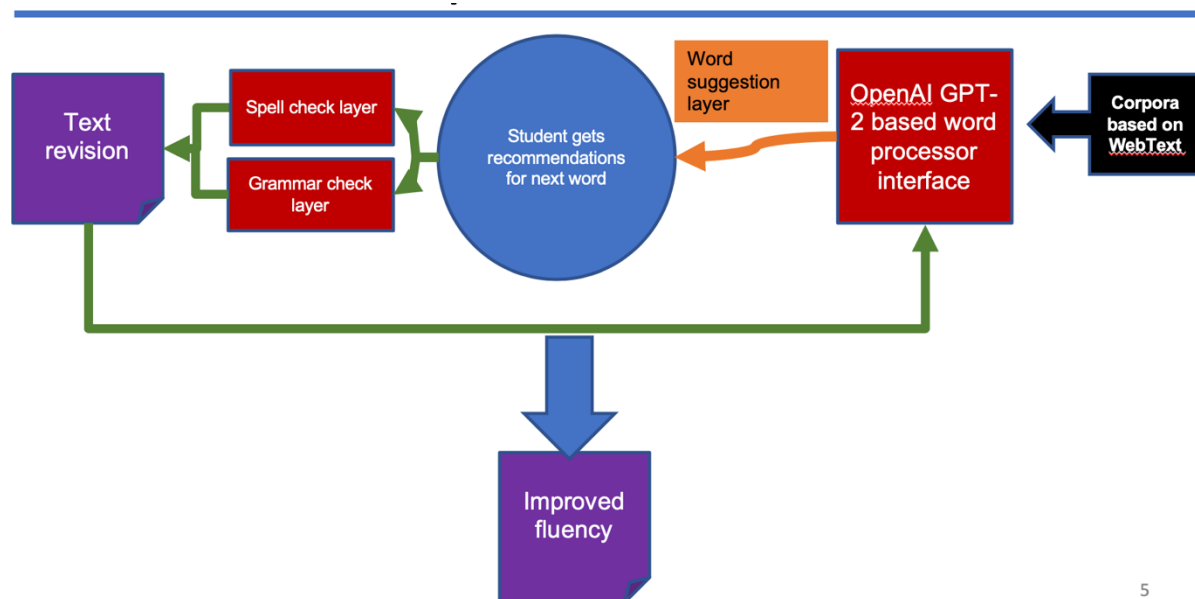
(1) Allen Institute for AI. Language Modeling Demo. https://demo.allennlp.org/next-token-lm?text=This%20research%20will%20

Impacts of Interconnecting with Korea on Japan's Electric Power Companies' Competitive Business Segments

Romain Zissler, D3, Energy Course, Working Adult Doctoral Program

Connecting Japan's electrical grid with those of neighboring countries may: provide economic benefits, help securing stability of supply, and indirectly support adoption of low cost RE on a large scale.

With the exception of Japan's transmission system operators (TSOs), major Northeast Asian TSOs in China, Korea and Russia are collaborating to advance the Asia Super Grid (ASG) concept that would interconnect these countries and Mongolia, to start with. Participation of Japan's power companies is critical to move forward with such project.

The goal of the thesis is to stimulate interest and encourage participation of Japan power companies in the ASG initiative by understanding why they could oppose such project, and then making proposals to address their potential concerns.

To do so, an assessment of the potential impacts of interconnecting Japan and Korea's electrical grids – potentially a decisive first step – on competitive business segments of Japan's power companies will be led.

A Symbolic Representation of Asia Super Grid

Source: Renewable Energy Institute, About "Asia Super Grid" (ASG) (accessed September 28, 2018)

First, empirical research indicates potential substantial economic savings from interconnecting the two countries. In both countries, generators would be losers and suppliers winners. In Japan, however, procurement savings of suppliers do not recover losses faced by generators.

Second, theoretical research is ongoing, focusing on computer modeling of the two power systems interactions – no result available yet.

Effect of hydrogen donors on the catalyzed hydrogenolysis of Kraft lignin

Abraham Castro Garcia, GEDES, M2, IGP-A (MEXT scholarship)

Lignocellulose such as wood and crop residue are abundant sources of renewable of biomass and is composed of 15-30% lignin by weight. Cellulose and hemicellulose fractions are used for making paper, but lignin is seen as a low-value waste product that is burnt as fuel to power the paper making process. Lignin is a complex polymer made of phenolic units. It is possible to transform this lignin into aromatic chemicals which are currently obtained only from oil, these chemicals are used for fuels, plastics and medicines. Hydrogenolysis reaction is used to transform lignin into aromatic chemicals by using only alcohols and water as a source of hydrogen together with a nickel catalyst, which is cheaper and safer than using hydrogen gas. Experiments are carried out in batch or bomb type reactors with different types of alcohols, temperatures, reaction times and other variables, the products consist mainly bio oil and is analyzed by GC-MS. The research objective is to find a combination of variables that optimize the quantity and quality of bio oil produced from lignin. In Figure 1, is shown the expected chemical reaction that happens at high temperature. Futhermore, novel mico-reactors were designed and fabricated at Tokyo Tech to promote the chemical reaction.
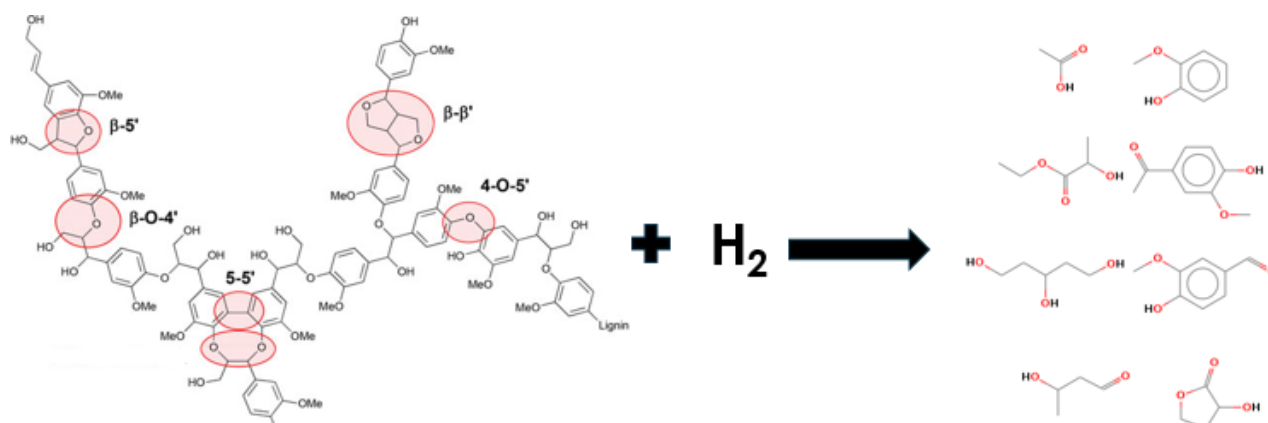

Figure 1. Lignin hydrogenolysis reaction

Energy Policy Group: All-day energy harvesting power system utilizing a thermoelectric generator with phase change materials-based heat storage

Yasuki Kadohiro, M2 Energy Course, Japanese (general) track

Among the renewable energy systems, the solar thermal systems, especially the solar hot-water systems which is mainly used for household, are considered as the most cost-effective alternatives of fossil fuels. Recently, those solar hot water systems are combined with a thermoelectric generator (TEG) and they are considered as one of the most promising systems. However, it is understood that those systems cannot generate electricity from sunset to sunrise when residential consumers use the most electricity. The literature describes several combination systems which can both generate the electricity and produce hot water, but all of the systems cannot generate electricity at all during the nighttime. In this research, an all-day energy harvesting power system utilizing a thermoelectric generator with phase change materials (PCMs) based heat storage will be developed to generate electricity all-day and to produce hot water. The research will advance prior research developed for undergraduate thesis research. The experimental and theoretical analysis of the system shown in Fig. 1 will be conducted to evaluate and verify the performance. If proven to be successful, this system is a viable source of electricity and hot water that has high cost-effectiveness and high compactness.
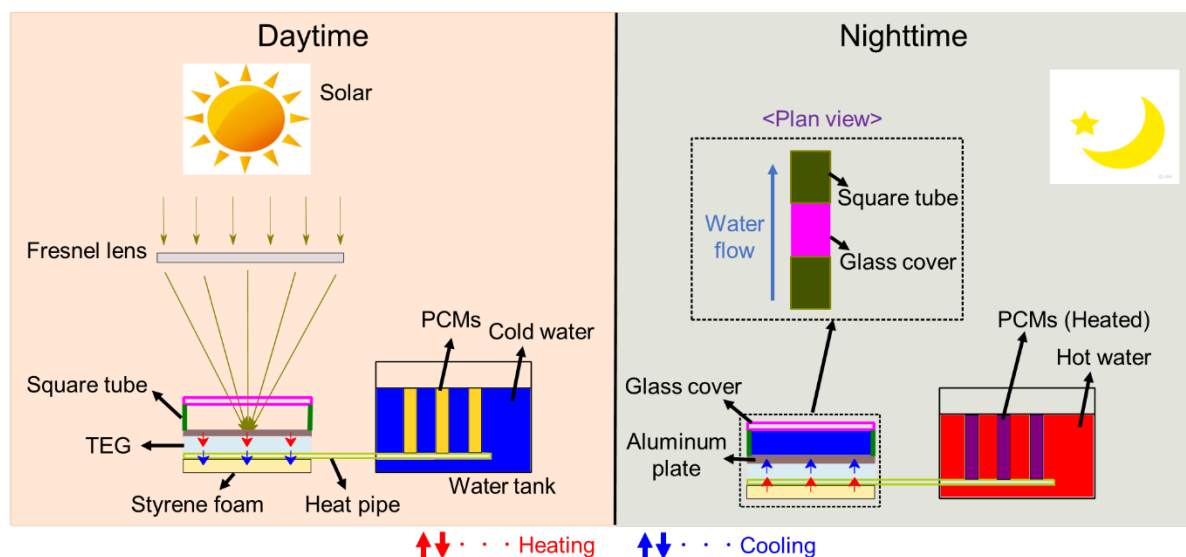

Fig 1. Schematic of the proposed system (Hot side in daytime: solar light, Cold side in daytime: cold water and PCMs, Hot side at nighttime: hot water and PCMs, Cold side at nighttime: cold water flow).

Biofuels Group: Optimization of Lignin Hydrogenolysis using Machine Learning

Liu Yin, M1, IGP-A, Materials Science and Engineering Dept.

Japan recently (Oct. 2020) announced that it would achieve carbon neutrality by 2050, which means a large reduction in greenhouse gas (GHG) emissions is urgently needed. To reduce GHG emissions, biofuels, prepared from biomass is an alternative, but to date is not an economic option due to biofuels' poor quality. Global biofuel production is expected to rise from 1.3 million barrels per day in 2010 to 2.7 million barrels per day in 2030 with current technology.

Lignocellulose, referring to plant dry matter, consists of lignin, hemi-cellulose and cellulose. Many methods have been developed for lignin depolymerization to produce bio-oil, among all of them, hydrogenolysis (reaction with hydrogen) produces the highest yields of lignin-based bio-oil. However, yield and selectivity are currently in sufficient to produce an economical biofuel. Optimization of reaction conditions including catalyst and reaction media for lignin hydrogenolysis is needed. Nowadays, Machine Learning already plays a big role not only in our daily life, but also in science and research. By combining information technology and material science, it is possible to accurately find optimized conditions for lignin hydrogenolysis.

Our research is aiming at using machine learning to solve the problem of optimizing lignin hydrogenolysis (see fig. below). We expect to determine the reaction conditions that will identify the best yield, selectivity, and the lowest cost. A machine learning derived literature database will be set up in order to summarize previous global high-yielding lignin hydrogenolysis results. Using this database, simulations will be run based on computer modeling and machine learning. Finally, multiple experiments will be carried out to verify the results and to propose key reaction pathways.
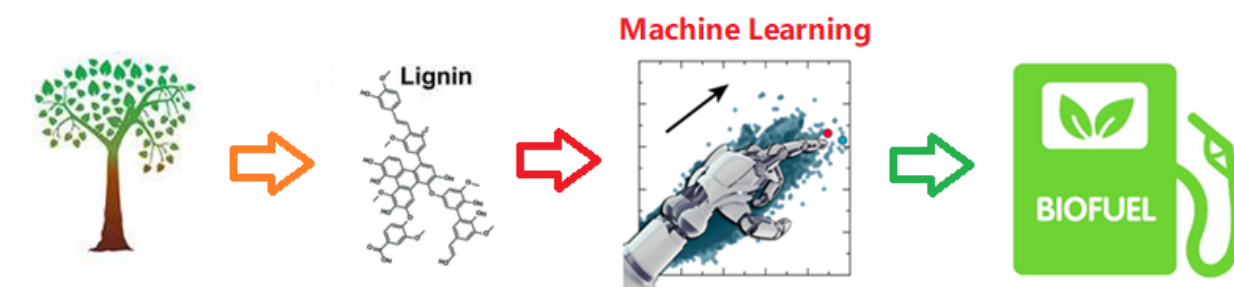
Overall process for conversion of lignin to biofuel using machine learning and chemical reaction engineering

Enhancement of Lipids Recovery Efficiency for Biodiesel Production from Wastewater Sludge by using Direct Lipids Extraction

Usman Muhammad, IGP-A (MEXT Scholarship), GEDES, M2

The increasing demands and use of petroleum fuels are harmful to the underground fossil fuels` level and environment as well. There is a growing interest of biofuels production to replace the fossil fuels by managing and utilization of wastes (biomass). Biodiesel is one of the promising biofuel produces from different edible and non-edible resources which has the same potential as petroleum diesel. Due to its feedstock and pre-treatment it has a great challenge of high production cost which ranges as $4.4 to $6.0 per liter. Sewage sludge has been tested as a potential source of biodiesel production because of high generation and free availability but still it has the same challenge of production cost in which drying process contributes >50%. Our new approach is to produce biodiesel by direct lipids extraction with elimination of drying process and efficient lipids recovery by using different extraction stages. Overall process flow for the lipids extraction is given below in fig.1.
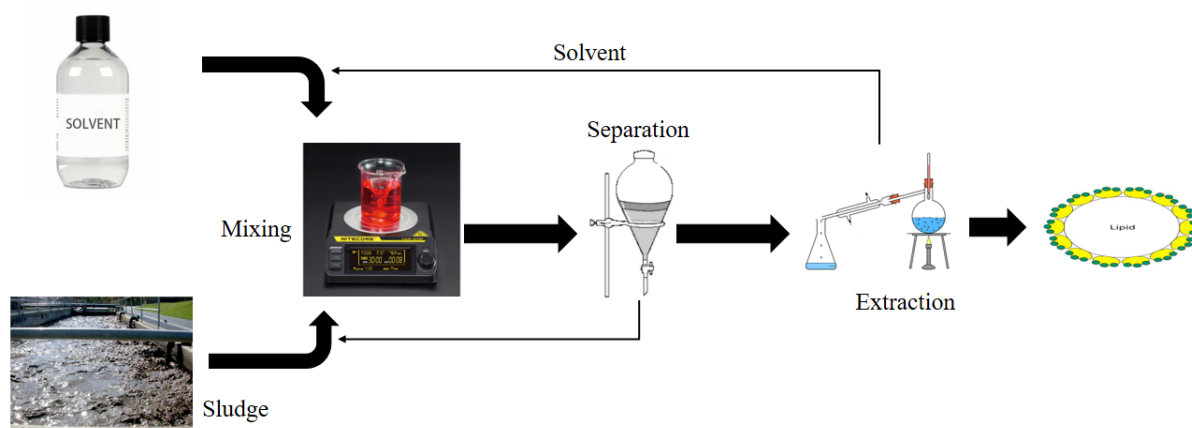

Figure 2: lipids extraction without drying process

Biofuels Group

Valorization of Bio-oil Produced from Pyrolysis of Spent Coffee Grounds

Tasya Muhamad Yasser, Energy Course M1 Student, Japanese program (general), (Moritani Scholarship Foundation Scholarship)

Spent coffee grounds (SCG) are the solid residues that remain after the brewing process of coffee. According to the International Coffee Organization (ICO), the production of coffee beans was estimated at 10 million tons in 2018. During the preparation of 1 kg of soluble coffee, approximately 2 kg of SCG are obtained, and it is considered as waste. However, even after the brewing process, SCG still has a high content of organic matter that can be used as biomass to be converted to obtain valuable products. Many research only focusing on how SCG can be used as a biofuel, and not considered as a chemical source. While SCG has a high content of organic matters, it is a promising and sustainable source for chemicals and could be a novel way for the valorization of SCG. In this study, we are doing pyrolysis to produce bio-oil since it is environmentally friendly (see fig. below). To gain more bio-oil, we are trying to introduce motor to our pyrolysis equipment and upgrade it to the fluidized-bed reactor. The bio-oil will analyze further with Gas Chromatography-Mass Spectrometry (GC-MS) to know its composition. In this research, we aim the valorization of SCG and paying respect to the environment.
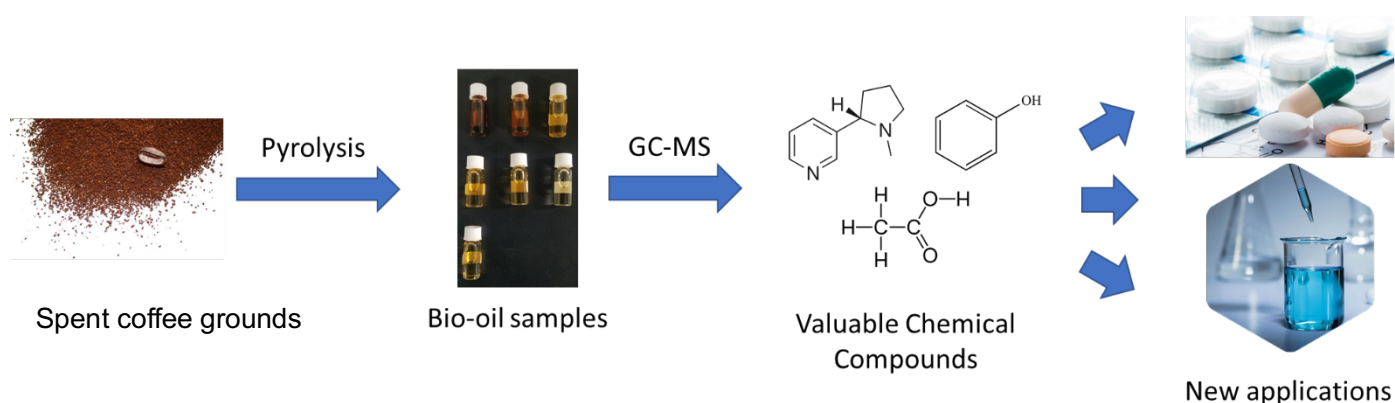
Overall process for conversion of spent coffee grounds to chemicals using machine learning and chemical reaction engineering

Development of community microgrid in urban residential area: Case study of Ulaanbaatar, Mongolia

Tumurbaatar Uyanga, Energy Course M1 student, IGP-C, (Nittori International Foundation Scholarship)

Microgrid (see fig. below) has been mainly seen as a solution for rural electrification integrating more renewable energy, and offering reliable power supply, however, in recent years, it's getting more attention in urban areas as well. Especially, in cities in developing country, various issues are entangled with energy issue, such as energy security, diversification, environmental and social problems etc. In this research, the microgrid development will be studied as an alternative solution to tackle various issues in Ulaanbaatar, Mongolia.

Having rich renewable energy resource, Mongolian energy system is heavily dependent coal which causes deadly air pollution yet imports 20% of electricity demand from Russia. Also, both the generation and transmission facility are exceeded their lifespan, thus requiring system upgrade in near future, to supply reliable, sustainable, and affordable electricity and heat to its increasing population. Through this research, the appropriate technology combination suited for local demand characteristics will be evaluated using Homer Pro software simulation and will be compared to previous projects done by the government in terms of economic and environmental impact.
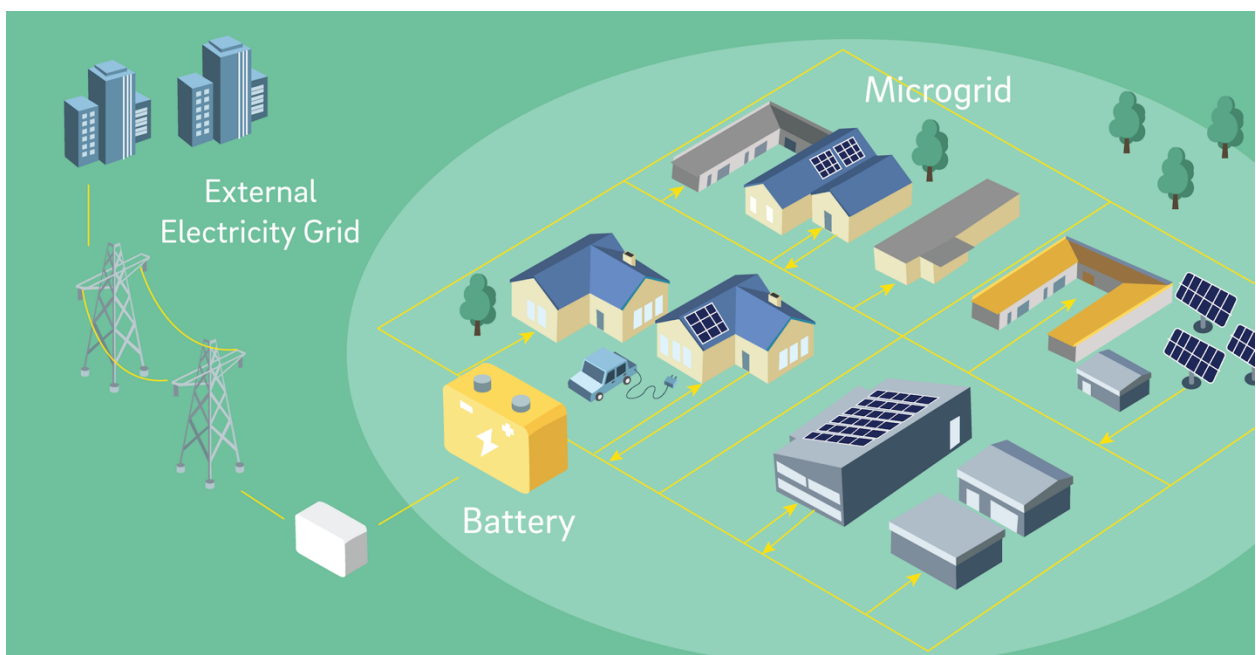
Microgrid, Source: Enova Energy

Blue carbon: The Dynamic Monitoring, Restoration and Carbon Sequestration Potentiality Evaluation of Seagrass Ecosystem in Tokyo Bay

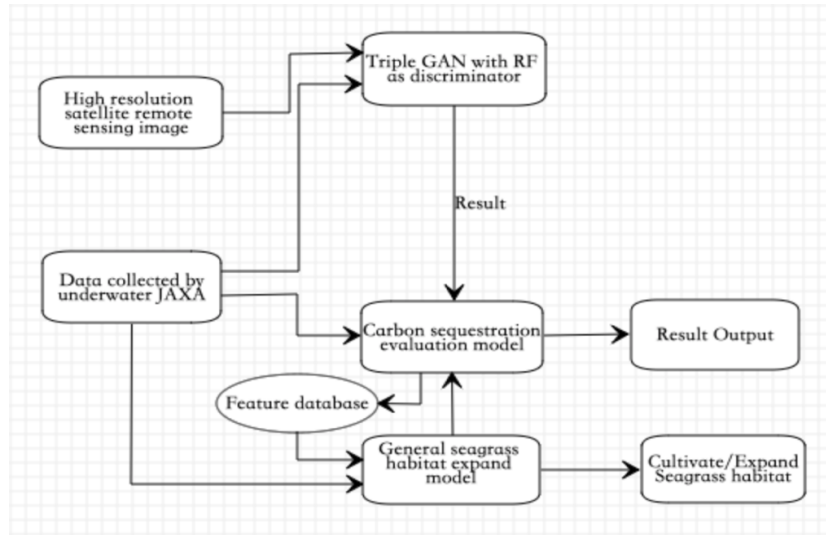Name: LIU HAO (Iris)   Energy Science and Engineering   Master 2nd year student

Figure 1. The general flowchart

Figure 2. Detection result of seagrass habitat in Tokyo Bay

When we talk about energy policy, the first thing comes to our mind is to reduce GHG (greenhouse gas) emission. Because ocean has enormous carbon sequestration potential, 93% of carbon dioxide in the earth is stored and recycled through the ocean. Meanwhile, the topic of blue carbon has appealed more and more researchers' interest. Given the situation of Tokyo Bay, thus, this research topic is to monitor, restore coastal ecosystem (mainly focus on Seagrass ecosystem now) in Tokyo Bay, evaluate the carbon sequestration ability through AI and big data technology. If you are interested in my research topic, please feel free to contact me to know more detail.

Like the figure 1 shows, this research combined Random Forest (RF) and Triple Generative Adversarial Networks (GAN) to deal with the data discontinuity problem of high-resolution satellite remote sensing images which is data augment. Then, use seawater data from JAXA, design carbon sequestration evaluation model and general habitat expand model to evaluate the carbon sequestration ability, restore expand the habitat.

Figure 2 shows the expected result of the Triple GAN with RF as discriminator, it can detect the target area clearly.