

## Purdue SMART Lab Highlights 2020

### January 2021



### Lab Overview

The Smart Machine and Assistive Robotics Technology (SMART) Lab was established by Dr. Byung-Cheol ("B.C.") Min in 2015 to research robot design & control, multi-robot systems, and human-robot interaction, with focus on applications in field robotics and assistive technology and robotics. Since the establishment of the SMART lab in 2015, 4 Postdocs, 2 PhD students, 5 MS students, 8 Undergrad students, 2 Visiting scholars, and 2 Visiting students have completed their research programs. In 2020, 1 Director, 1 Postdoc, 8 PhD students, 3 MS students, and 5 Undergrad students were associated with the lab.

### New Equipment

- In 2020, the lab's new highlighted equipment includes mobile robot platforms, sonar sensors, drones, and 2 desktop PCs with GPU.

### Lab Media Appearances

- One of the lab's collaboration works was featured in the Purdue Polytechnic's Newsroom – "Realistic-looking, high-tech gloves designed to not be noticed".
- Shyam Kannan and Dr. Min's efforts in the Indy Autonomous Challenge was featured in the Purdue University's Newsroom – "Purdue, West Point to partner on autonomous race car; will take on Brickyard in 2021", and Purdue Polytechnic's Newsroom – "Polytechnic students to race autonomous cars at Indianapolis Motor Speedway".

### Lab Meetings/Seminars

#### *Lab Meetings*

- 34 lab group meetings were held in 2020; 10 in-person and 24 virtual meetings. During the 2020 spring semester, the lab had a group meeting every Fridays from 2pm to 4pm in the POTR facility and via WebEx (during the pandemic). During the 2019 fall semester, the lab had a group meeting every Fridays from 2pm to 4pm via Microsoft Teams.

#### *Lab Seminars*

- 4 technical seminars on Machine Learning and ROS, Robust Control, Web Programming, and Reinforcement Learning were delivered by PhD students.
- 9 paper review seminars were delivered by PhD students and MS students.

### Lab Members

#### *Current Members (11)*

- **Byung-Cheol Min** (Director) was promoted to Associate Professor in August 2020. He received the Focus Award from Purdue University in recognition of his dedication to disability and accessibility.
- **Jun Han Bae** (PhD Student) was a RA for Prof. Richard Voyles and Dr. Min. He published 1 journal paper as a first author and presented 1 poster as a first author. He received the Best Presentation Award, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session in November 2020. Jun Han mentored 2 undergrad students.
- **Sangjun Lee** (PhD Student) was a RA for Dr. Min and continued his research with the NIJ fellowship. He submitted 1 conference paper as a first author.
- **Manoj Penmetcha** (PhD Student) was a GA for the Purdue's Library. He defended his doctoral proposal in April 2020. He published 1 conference paper as a first author. Manoj delivered a lab technical seminar on Web Programming.

- **Wonse Jo** (PhD Student) was a RA for Dr. Min. He defended his doctoral proposal in August 2020. He published 3 journal papers as a co-author and 2 conference papers; 1 as a first author and 1 as a co-author, submitted 1 journal paper and 1 conference paper as a co-author, and presented 5 posters; 2 as a first author and 3 as a co-author. He received the Best Presentation Award, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session in November 2020. He served as a lab committee chair for the fall semester. Wonse also mentored 4 undergrad students.
- **Shyam Kannan** (PhD Student) was a TA for Prof. Ravai in the spring semester, and a RA for Dr. Min in the summer and fall semesters. He passed his preliminary exam in December 2020. He published 2 journal papers as a co-author and 3 conference papers; 1 as a first author and 2 as a co-author, submitted 1 journal paper as a co-author and 2 conference papers; 1 as a first author and 1 as a co-author, and presented 2 posters; 1 as a first author and 1 as a co-author. He delivered a lab technical seminar on Machine Learning and ROS. He received the 2020-21 Purdue PRF Graduate Fellowship in April 2020, a Purdue Graduate Student Scholarship in May 2020, and the Best Presentation Award, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session in November 2020. Shyam was also recognized as the Member of the Year for 2019-20 by SMART Lab.
- **Su Sun** (PhD Student) was a TA for Prof. Ravai in the spring semester, and for Dr. Min in the fall semester. She started her PhD study in January 2020. She received a Purdue Graduate Student Scholarship in May 2020. Su served as a lab committee member for the spring and fall semesters.
- **Jeremy Pan** (MS Student) was a TA for Prof. Laux in the spring semester, and for Prof. Barlow in the fall semester. He defended his MS proposal in December 2020. His thesis topic is adaptive user interface development for intuitive robot control.
- **Go-Eum** (MS Student) was a TA for Prof. Laux in the fall semester. She started her MS study under Dr. Min's supervision in March 2020. She defended her MS proposal in April 2020 and her MS thesis in December 2020. She continues her study pursuing her PhD under Dr. Min's supervision. She published 1 conference paper as a co-author, submitted 1 conference paper as a co-author, and presented 1 poster as a first author. She received the Best Presentation Award, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session in November 2020, and received a Purdue Graduate Student Scholarship in May 2020. Go-Eum served as a lab committee member for the fall semester.
- **Jaeun Kim** (Undergrad Student) worked as an undergraduate research assistant for Dr. Min. She presented 1 poster as a first author. Jaeun received a 2020-21 OUR Scholarship from The Office of Undergraduate Research at Purdue University.
- **Pou Hei (Gavin) Chan** (Undergrad Student) worked as an undergraduate research assistant for Dr. Min. Gavin presented 3 posters; 1 as a first author and 2 as a co-author.

#### *Lab Alumni (7)*

- **Ahreum Lee** (Postdoc) completed her postdoc training at Purdue in August 2020 and moved to the University of Eastern Finland to continue her research under Dr. Roman Bednarik as a postdoctoral researcher. She published 1 journal paper as a first author and 1 conference paper as a co-author, and submitted 2 conference papers as a co-author.
- **Shaocheng Luo** (PhD Student) completed his PhD in May 2020 and moved to the University of Alberta to continue his research under Prof. Hong Zhang as a postdoctoral researcher. He published 2 journal papers; 1 as a first author and 1 as a co-author, and submitted 1 journal paper as a co-author. He was a lecturer for CNIT 161 - Introduction to Programming and Data Management for Smart Manufacturing in the spring semester. Shaocheng delivered a lab technical seminar on Reinforcement Learning. Shaocheng served as a lab committee chair for the spring semester.
- **Tamzidul Mina** (PhD Student) completed his PhD in December 2020 and moves to the Sandia National Labs to continue his research as a postdoctoral researcher. He was a TA in the School of Mechanical Engineering. He published 2 journal papers as a first author, submitted 1 journal paper as a first author, and presented 1 poster as a co-author. He delivered a lab technical seminar on Robust Control, and served as a lab committee member for the spring semester. Tamzid received the Magoon Award for Outstanding Teaching Assistants from the College of Engineering, Purdue University in April 2020.

- **Jee Hwan Park** (MS Student) completed his MS in August 2020 and joined LG Innotek. He was a TA for Dr. Min in the spring semester. Jee Hwan published 1 journal paper as a co-author.
- **Yuta Hoashi** (Undergrad Student) completed his BS in May 2020 and started his MS at Carnegie Mellon University in the fall semester.
- **Walter Kruger** (Undergrad Student) worked as an undergraduate research assistant for the CAREER project in the spring semester.
- **Andrew Sakai** (Undergrad Student) worked as an undergraduate research assistant for the Robotic Water Quality Monitoring Project.

#### *New Lab Members (2)*

- **Su Sun** (PhD Student) joined the lab in January 2020 as a direct PhD student. She obtained her BS degree in Digital Media Technology from North China University of Technology. Su's research interests include localization and perception for autonomous robots.
- **Go-Eum** (MS Student) joined the lab in March 2020. She obtained her BS degree in Computer Science & Engineering from Soongsil University. Go-Eum's research interests include HRI, computer vision, and deep learning.

#### **Faculty Accomplishments & Awards (2)**

- Dr. Min got promoted to Associate Professor in August 2020.
- Dr. Min received the Focus Award from Purdue University in recognition of his dedication to disability and accessibility in March 2020.

#### **Student Accomplishments & Awards (12)**

##### *Fellowships*

- Shyam Kannan received a 2020-21 Purdue Research Foundation (PRF) Graduate Fellowship in April 2020.

##### *Awards*

- Tamzidul Mina received the Magoon Award for Outstanding Teaching Assistants from the College of Engineering, Purdue University in April 2020.

##### *Scholarships*

- Su Sun received a Purdue Graduate Student Scholarship in May 2020.
- Shyam Kannan received a Purdue Graduate Student Scholarship in May 2020.
- Go-Eum Cha received a Purdue Graduate Student Scholarship in May 2020.
- Jaeun Kim received a 2020-21 OUR Scholarship from The Office of Undergraduate Research at Purdue University in May 2020.

##### *Competitions*

- Wonse Jo, Shyam Kannan, and Dr. Min, teamed up with Prof. Jongheok Kim's group at Hongik University in South Korea, completed the qualification round in the NASA Space Robotics Challenge Phase 2 in October 2020.
- Shyam Kannan and Dr. Min, teamed up with other researchers at Purdue and West Point (United States Military Academy), participate in the Indy Autonomous Challenge, and the team was accepted into Round 2 in March 2020.

##### *Poster/Paper Awards*

- Jun Han received the Best Presentation Award, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session in November 2020.
- Wonse Jo received the Best Presentation Award, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session in November 2020.
- Shyam Kannan received the Best Presentation Award, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session in November 2020.
- Go-Eum Cha received the Best Presentation Award, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session in November 2020.

**Grant Proposal Submitted (12, \$8.4M)***Awarded*

- PRF Research Grants: Human-Delivery Robot Social Interaction for Last-mile Delivery, Role: PI, Sponsor: Purdue University, Amount: \$31,119 (05/10/2020 – 09/15/2021).
- Reconfigurable Cyber-Physical Simulators for Multi-Robot Systems, Role: PI, Sponsor: Purdue Polytechnic Institute, Amount: \$8,000 (08/01/2020 – 06/30/2021).
- Wheeled Mobile Parallel Robots with Hybrid Moving and Manipulation Functions, Role: Co-PI (PI: Dongming Gan), Sponsor: Purdue Polytechnic Institute, Amount: \$8,000 (08/01/2020 – 06/30/2021).

*Pending*

- Empowering Delivery Robots with an Intelligent Delivery Spot Localization System, Role: PI, Sponsor: Sony, Amount: \$100,000 (05/01/2021 – 04/30/2022).
- Empowering Delivery Robots with a Human Courier Model, Role: PI, Sponsor: Amazon, Amount: \$82,000 (07/01/2021 – 06/30/2022).
- A Decentralized and Secure Situational-Awareness Architecture for Cooperative Unmanned Surface Vehicles, Role: Co-PI (PI: Jin Kocsis), Sponsor: Office of Naval Research, Amount: \$430,653 (03/01/2021 – 02/28/2024).
- Smart Campus Navigation System for Blind or Visually Impaired People, Role: PI, Sponsor: Google, Amount: \$60,000 (07/01/2021 – 06/30/2022).
- AI Institute: Institute for eXplainable Fuzzy AI (XF-AI) , Role: Co-PI (PI: Julia Rayz), Sponsor: University of Cincinnati, Amount: \$1,227,440 (07/01/2021 – 06/30/2026).

*Declined*

- NRI: FND: Human-Delivery Robot Social Interaction for Final-feet Delivery, Role: PI, Sponsor: National Science Foundation, Amount: \$622,547 (08/01/2020 – 07/31/2023).
- FW-HTF-P: Towards Human-Intelligent Technology Ecosystem: A Transformative and Assured Human Multi-Robot Paradigm for Future Construction Industry, Role: Co-PI (PI: Jin Kocsis), Sponsor: National Science Foundation, Amount: \$150,000 (10/01/2020 – 09/30/2021).
- Use of Tapping Sound to Identify Material Type for Mobile Robots Exploration and Mapping Applications, Role: PI, Sponsor: Office of Naval Research Global, Amount: \$720,000 (09/01/2020 – 03/31/2022).
- A Low-Cost Cooperative and Proactive Situational-Awareness and Response System for In-time Adaptive Aviation Safety Management, Role: Co-PI (PI: Jin Kocsis), Sponsor: National Aeronautics and Space Administration (NASA), Amount: \$5,000,000 (09/01/2021 – 08/31/2025).

**Grants Awarded (3, \$47K)**

- PRF Research Grants: Human-Delivery Robot Social Interaction for Last-mile Delivery, Role: PI, Sponsor: Purdue University, Amount: \$31,119 (05/10/2020 – 09/15/2021).
- Reconfigurable Cyber-Physical Simulators for Multi-Robot Systems, Role: PI, Sponsor: Purdue Polytechnic Institute, Amount: \$8,000 (08/01/2020 – 06/30/2021).
- Wheeled Mobile Parallel Robots with Hybrid Moving and Manipulation Functions, Role: Co-PI (PI: Dongming Gan), Sponsor: Purdue Polytechnic Institute, Amount: \$8,000 (08/01/2020 – 06/30/2021).

**Current Funded Research Projects (10, \$3.2M)**

- PRF Research Grants: Human-Delivery Robot Social Interaction for Last-mile Delivery, Role: PI, Sponsor: Purdue University, Amount: \$31,119 (05/10/2020 – 09/15/2021).
- Reconfigurable Cyber-Physical Simulators for Multi-Robot Systems, Role: PI, Sponsor: Purdue Polytechnic Institute, Amount: \$8,000 (08/01/2020 – 06/30/2021).
- Wheeled Mobile Parallel Robots with Hybrid Moving and Manipulation Functions, Role: Co-PI (PI: Dongming Gan), Sponsor: Purdue Polytechnic Institute, Amount: \$8,000 (08/01/2020 – 06/30/2021).

- CAREER: Adaptive Human Multi-Robot Systems, Role: PI, Sponsor: National Science Foundation, Amount: \$500,000 (02/15/2019 – 01/31/2024).
- CPS: Medium: Collaborative Research: Closed Loop Sustainable Precision Animal Agriculture, Role: Co-PI (PI: Richard Voyles), Sponsor: National Institute of Food and Agriculture, Amount: \$541,448 (09/01/2018 – 08/31/2021).
- PFI-RP: Partnerships for Innovation in Interoperable Building Information Modeling Technology for Applications in Automated Building Code Compliance Checking and Modular Construction Automation, Role: Co-PI (Jiansong Zhang), Sponsor: National Science Foundation, Amount: \$915,597 (09/15/2018 – 08/31/2021).
- UNSA NEXUS: Robotic Water Quality Monitoring and Distribution Systems: A Pilot Study, Role: PI, Sponsor: Universidad Nacional de San Agustin, Amount: \$365,439 (01/01/2018 – 5/31/2021).
- Cybersecurity and Safety Challenges in Autonomous Vehicles: Threats Identification and Countermeasures Development, Role: PI, Sponsor: National Institute of Justice, Amount: \$147,131 (08/01/2017 – 5/31/2021).
- I/UCRC Phase I: Robots and Sensors for the Human Well-being, Role: Senior Personnel (PI: Richard Voyles), Sponsor: National Science Foundation, Amount: \$637,202 (09/15/2014 – 08/31/2021).
- Polytechnic Post-Doc Support Competition Award, Role: Co-PI (PI: Sunghwan Lee), Sponsor: Purdue University, Amount: \$50,000 (7/01/2020 – 08/31/2021)

## **Publications (8 journals, 3 conferences, 1 archive, 2 paper under review, 3 papers rejected)**

### *Journals*

- Ahreum Lee, Wonse Jo, Shyam Sundar Kannan, and Byung-Cheol Min, “Investigating the Effect of Deictic Movements of a Multi-robot”, *International Journal of Human-Computer Interaction*, 2020.
- Tamzidul Mina, Shyam Sundar Kannan, Wonse Jo, and Byung-Cheol Min, “Adaptive Workload Allocation for Multi-human Multi-robot Teams for Independent and Homogeneous Tasks”, *IEEE Access*, Vol. 8, pp. 152697-152712, 2020.
- Tamzidul Mina, Yogang Singh, and Byung-Cheol Min, “Maneuvering Ability-Based Weighted Potential Field Framework for Multi-USV Navigation, Guidance and Control”, *Marine Technology Society Journal*, Vol. 54, No. 4, pp. 40-58, 2020.
- Jun Han Bae, Wonse Jo, Jee Hwan Park, Richard M. Voyles, Sara K. McMillan and Byung-Cheol Min, “Evaluation of Sampling Methods for Robotic Sediment Sampling Systems”, *IEEE Journal of Oceanic Engineering*, Early Access, 2020.
- Shaocheng Luo, Jonghoek Kim, and Byung-Cheol Min, “Asymptotic Boundary Shrink Control with Multirobot Systems”, *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, Early Access, 2020.
- Patchara Kitjacharoenchai, Byung-Cheol Min, and Seokcheon Lee, “Two Echelon Vehicle Routing Problem with Drones in Last Mile Delivery”, *International Journal of Production Economics*, Vol. 25, 2020.
- Ho Young Jeong, David J. Yu, Byung-Cheol Min, and Seokcheon Lee, “The Humanitarian Flying Warehouse”, *Transportation Research Part E: Logistics and Transportation Review*, Vol. 136, April 2020.
- Ramvijas Parasuraman, Jonghoek Kim, Shaocheng Luo, and Byung-Cheol Min, “Multipoint Rendezvous in Multirobot Systems”, *IEEE Transactions on Cybernetics*, Vol. 50, Issue 1, pp. 310-323, Jan. 2020.

### *Conferences*

- Shyam Sundar Kannan, Wonse Jo, Ramvijas Parasuraman, and Byung-Cheol Min, “Material Mapping in Unknown Environments using Tapping Sound”, 2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2020), Las Vegas, NV, USA, 25-29 October, 2020.
- Manoj Penmetcha, Shyam Sundar Kannan, and Byung-Cheol Min, “Smart Cloud: Scalable Cloud Robotic Architecture for Web-powered Multi-Robot Applications”, 2020 IEEE International Conference on Systems, Man and Cybernetics (SMC), Toronto, Canada, 11-14 October, 2020.

- Wonse Jo, Shyam Sundar Kannan, Go-Eum Cha, Ahreum Lee, and Byung-Cheol Min, “ROSBAG-based Multimodal Affective Dataset for Emotional and Cognitive States”, 2020 IEEE International Conference on Systems, Man and Cybernetics (SMC), Toronto, Canada, 11-14 October, 2020.

#### *Archives*

- Wonse Jo, Shyam Sundar Kannan, Go-Eum Cha, Ahreum Lee, and Byung-Cheol Min, “A ROS-based Framework for Monitoring Human and Robot Conditions in a Human-Multi-robot Team”, arXiv preprint, 2020.

#### *Papers Under Review*

- Tamzidul Mina, Shyam Sundar Kannan, Wonse Jo, Shaocheng Luo, Galen B. King, and Byung-Cheol Min, “Distributed Multi-robot Arbitrary Object Transportation with Pushing Surface Identification and Model-based Pushing Effort Regulation”, IEEE Transactions on Systems, Man and Cybernetics: Systems.
- Sangjun Lee and Byung-Cheol Min, “Distributed Control of Multi-Robot Systems in the Presence of Deception and Denial of Service Attacks”, 2021 IEEE International Conference on Robotics and Automation (ICRA), Xi’an, China, May 30 – June 5, 2021.

#### *Papers Rejected*

- Shyam Sundar Kannan, Ahreum Lee, and Byung-Cheol Min, “External Human-Machine Interface on Delivery Robots: Expression of Navigation Intent of the Robot”, 2021 ACM/IEEE International Conference on Human-Robot Interaction, Boulder, Colorado, March 08-11, 2021.
- Upinder Kaur, Xin Ma, Byung-Cheol Min, Richard Voyles, and Shih Hung, “Signature-based Unsupervised Malware Detection for Cyber-Physical Systems”, ACM/IEEE 12th International Conference on Cyber-Physical Systems (ICCPS 2021), Nashville, TN, USA, May 19-21, 2021.
- Upinder Kaur, Xin Ma, Richard M. Voyles, and Byung-Cheol Min, “Malware Detection Using Pseudo Semi-Supervised Learning”, The Thirty-Third Annual Conference on Innovative Applications of Artificial Intelligence (IAAI-21), Virtual Conference, 2-9 February, 2021.

### Poster Presentations (7)

- Wonse Jo, Tamzidul Mina, Shyam Sundar Kannan, and Dr. Byung-Cheol Min, “Affective Adaptive Control System for Multi-human Multi-robot Teams”, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session, Purdue University, November 2020. **[Best Presentation Award]**
- Go-Eum Cha, Wonse Jo, and Byung-Cheol Min, “Human Cognitive Load Prediction with Behavioral Cues for Human-Machine Interaction”, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session, Purdue University, November 2020. **[Best Presentation Award]**
- Jaeun Kim, Wonse Jo, and Byung-Cheol Min, “Development of an Open-source Mobile Robot Platform for Multi-robot systems”, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session, Purdue University, November 2020.
- Jun Han Bae, Pou Hei Chan, Shyam Sundar Kannan, Richard M. Voyles, Mauricio Postigo-Malaga, and Byung-Cheol Min, “Unmanned Sediment Sampling System for Surface Water Sediment Collection”, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session, Purdue University, November 2020. **[Best Presentation Award]**
- Shyam Sundar Kannan and Byung-Cheol Min, “Short Term Human-Delivery Robot Interaction with Adaptive Intent Expression”, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session, Purdue University, November 2020. **[Best Presentation Award]**
- Pou Hei Chan, Wonse Jo, Chad T. Jafvert, Mauricio Postigo-Malaga, and Byung-Cheol Min, “Vertically Symmetrical Unmanned Surface Vessel (VSUSV) for Bathymetric and Water Quality Surveys of Surface Waters”, 2020 Fall the Realizing the Digital Enterprise (RDE) Mini-Talk Session, Purdue University, November 2020.
- Wonse Jo, Pou Hei Chan, Chad T. Jafvert, Mauricio Postigo-Malaga, and Byung-Cheol Min, “Development of Reversible USV platform for Bathymetric Survey in Various Water Resources”, 2020 Environmental Research Expo, Purdue University, October 2020.

**Tutorials (2)**

- Jaeun Kim, Wonse Jo, and Byung-Cheol Min, “A Guide to Building a ROS2-based Mobile Robot Platform: SMARTmBot”, GitHub, December 2020.
- Tamzidul Mina, “ Robust Control Tutorial”, GitHub, April 2020.

**Invited Talks (1)**

- Byung-Cheol Min, “Towards Adaptive Human Multi-Robot Systems”, Colloquium on Multimedia Computing Systems 2020, Sungkyunkwan University, Seoul, South Korea, November 2020.

**Outreaches (1)**

- Wonse Jo, Jaeun Kim, and Dr. Min conducted a virtual outreach event for K-12 students at the Purdue Polytechnic High School (PPHS) as part of the NSF CAREER project, November 2020.

**Lab Social Media***YouTube Channel*

- 7 new videos published; 1) “Purdue SMART (Smart Machine and Assistive Robotics Technology) Lab Overview” in August 2020, 2) “Adaptive Workload Allocation for Multi-human Multi-robot Teams - Supplementary video” in August 2020, 3) “Investigating the Effect of Deictic Movements of a Multi-robot - Supplementary video” in August 2020, 4) “Material Mapping in Unknown Environments using Tapping Sound - Supplementary video” in July 2020, 5) “Asymptotic Boundary Shrink Control with Multirobot Systems - Supplementary video” in June 2020, 6) “Evaluation of Sampling Methods for Robotic Sediment Sampling Systems - Supplementary video” in June 2020, and 7) “[SMARTBoat 5] Unmanned Surface Vehicle for Harmful Algae Removal” in February 2020.
- 3,250 video views and 25 new subscribers.

*Facebook Page*

- 29 new posts published.
- 559 page views and 148 post likes.

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