Special session：

SICE-JSAE-AIMaP Advanced Automotive Control

Organizer:
Taketochi Kawabe (Kyusyu University, SICE-JSAE Automotive Control and Modeling)
Yoshihiro Mizoguchi (Kyusyu University, AIMaP)
Co-organizer
Junichi Kako (Toyota Motor Cooperation)
Masakazu Mukai (Kogakuin University)
Yuji Yasui (Honda R&D Co., Ltd.)

Background

The automotive industry is currently undergoing a once in a century transformation aimed at reducing traffic accidents, realizing carbon neutral society and providing new values of movement. Because the automotive technologies have to be significantly evolved in order to meet new requirements such as carbon neutral, CASE, etc., the expectation for AI (artificial intelligence), machine learning, advanced control, optimization and mathematics has been increased year by year. Consequently, SICE-JSAE Automotive Control and Modeling Technical Committee established by SICE (The Society of Instrument and Control Engineer) and JSAE (Society of Automotive Engineers of Japan, Inc.) has conducted various activities with AIMaP (Advanced Innovation powered by Mathematics Platform). In this special session, the collaboration of latest automotive technology and mathematics will be introduced and discussed.

Program

SICE-JSAE-AIMaP Advanced Automotive Control and Mathematics I

Chair: Taketochi Kawabe (Kyusyu University)

8th September 2021 (Wednesday)
14:15-14:45 (30min) “Efficient lightweight solvers for real-time embedded nonlinear MPC”
Andreas Themelis (Kyusyu University)
14:45-15:15 (30min) “Application of energy optimal control to hybrid electric vehicle”
Hiroshi Uchida (Fukuyama University)
15:15-15:45 (30min) “Research of the optimization methodology for advanced powertrain control”
Masato Hayasaka (Toyota Motor Corporation)

SICE-JSAE-AIMaP Advanced Automotive Control and Mathematics II

Chair: Yoshihiro Mizoguchi (Kyusyu University)

8th September 2021 (Wednesday)
16:00-16:30 (30min) “Expectations for mathematical science researchers in the field of autonomous driving technology”
Ichiro Hagiwara (Meiji University)
16:30-17:00 (30min) “Topological methods for causal inference from time-series data”
Shizuo Kaji (Kyusyu University)
17:00-17:30 (30min) “Automated driving and driving assistance systems using cooperative intelligence”
Yuji Yasui (Honda R&D Co., Ltd.)

Speaker and Presentation Information

Andreas Themelis

Associate Professor
Kyusyu University

Presentation title:
Efficient lightweight solvers for real-time embedded nonlinear MPC

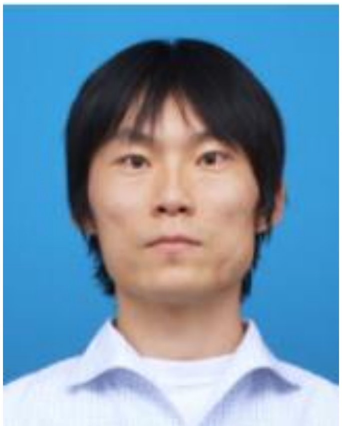
Abstract:
Model predictive control (MPC) has become a popular strategy to implement feedback control loops for a variety of systems. Since most systems are nonlinear by nature, nonlinear MPC offers a more accurate modeling, but it leads to nonconvex and much more complicated problems that need to be solved at every sampling step. In "embedded" applications such as autonomous driving, the resulting problems easily become of large scale and the sampling time can be as low as few milliseconds, thus imposing an imperative demand for algorithmic speed and efficiency. In this talk we show how the scalability properties of "proximal algorithms" can conveniently be employed to design certifiable, fast, and lightweight algorithms perfectly suited for embedded applications.

Hiroshi Uchida

Professor
Fukuyama University

Presentation title:
Application of energy optimal control to hybrid electric vehicle

Abstract:
The stability of energy optimal control (EOC) when the hybrid electric vehicle performs self-driving with speed control is verified by simulation and numerical calculation. As for the effects of the dead time of acceleration and velocity feedback, simulation that add dead time stepwise to both feedback results in negligible control error even if the dead time up to 40 ms (equivalent to 4 cycles of control loop) is given. As for the convergence of control, since the necessary and sufficient condition for the solution of the Euler-Poisson equation gives the minimum value of the evaluation function is that the second variation of the evaluation function is positive, the second variation of the evaluation function for both control law of engine and motor are calculated. As a result, it was shown that the engine control law is positive over the whole operation area on the torque-angular velocity plane, and it is the optimum solution over the whole operation area. Regarding the motor control law, although a part of the locus passes through the negative region, most of it exist within the positive region, indicating that the motor operated generally under the condition that the evaluation function had a minimum value.



Masato Hayasaka

Project Manager
Toyota Motor Cooperation

Presentation title:
Research of the optimization methodology for advanced powertrain control

Abstract:
Vehicle powertrain systems tend to be electrified in order to achieve carbon neutral. And development and the choice of various systems are necessary to meet different economic environment and energy policy, industrial policy and the needs of the customer every country, area. For advanced powertrain planning, we have to choose the best powertrain system from among many candidates expected by evaluating their potential correctly. Recent years, it has been clarified that some optimization methodologies are effective for potential evaluation of powertrain systems by obtaining optimal input time trajectory without any tailored controller. In this study, existing optimization methodology is improved to have wider coverage of powertrain system configurations. With proposed optimization methodology, the best input time trace is successfully achieved for fuel economy optimization of parallel-hybrid system.

Ichiro Hagiwara

Distinguished professor emeritus
Meiji University

Presentation title:
Expectations for mathematical science researchers in the field of autonomous driving technology

Abstract:
Cars are now so popular that even from the general public, you can see what is being actively researched and developed now in the automobile industry. That is exactly the self-driving. Recently level 3 car was released where the system is responsible for driving until the system becomes difficult to drive. And at that time , the system entrusts driving to the driver. In this case the driver must keep getting more nervous than driving himself although it should be automatic driving for relaxation which gives the birth to the public opinion that level 3 is difficult in the first place. To realize the level 3 that should be, the system must explain the driver what and how the driver should do which necessitates to be installed causal machine learning system on the self-driving car.

It is expected to achieve level 4 quickly for regional revitalization where the self-driving is limited location and time. For level 4, remote monitoring system is used in such way that it can be easily monitored multiple self-driving cars by one person because one of the biggest expectations for the self-driving is to carry out transportation infrastructure with a small number of people. It also necessitates the causal machine learning and high-speed, high-precision image processing technology for this remote monitoring system.

As far as level 5, there is a problem "Safe but not relief" which requests technologies to achieve a higher level of ride quality. Among these technologies, it can be listed up origami engineering for realizing vibration isolation in the frequency band that affects ride comfort and generalization of energy control method for real time optimal control method. And also it is expected relief can be unraveled from deep mathematical point of view. The lecture will focus on the above.

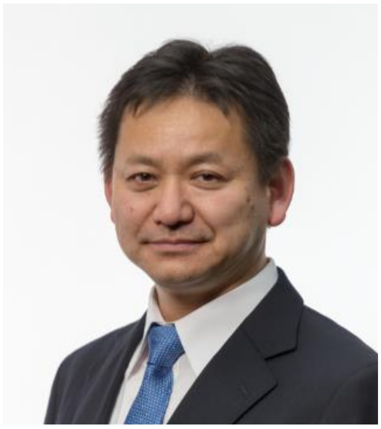
Shizuo Kaji

Professor
Institute of Mathematics for Industry, Kyushu University

Presentation title:
Topological methods for causal inference from time-series data

Abstract:
The real world consists of a lot of inter-related systems that evolve over time. Understanding and modelling such relations is the main topic of (data) science. Given two systems, detecting causality between them is an important task. It is particularly difficult when we cannot intervene in the systems but can only observe their behaviors. In this talk, we give an overview of causal inference from observed data. There are mainly two approaches in causal inference that differ in the fundamental assumption for the system; deterministic or probabilistic. We mainly focus on the former case. We discuss the idea of topological methods, including the widely-used "convergent cross mapping (CCM)" and its variants, that do not require the underlying model identification and applicable to complex non-linear systems.

Yuji Yasui



Executive Chief Engineer
Honda R&D Co. Ltd
Innovative Research Excellence

Presentation title:
Automated driving and driving assistance systems using cooperative intelligence

Abstract:
Honda has developed advanced driving assistance and automated driving vehicles (hereafter, AD/ADAS vehicle) in order to realize "collision-free society" and to provide many people "joy and freedom of mobility. The vehicles with automation functions were released as driving support system for highway, and its autonomous level has been updated from Level2 to Level3 step by step while keeping wide operational design domain (ODD). However, there was huge technical gaps between Level2 and Level3. Honda released the AD/ADAS vehicle equipped with Level3 function for traffic jam situation on highway. In this session, how Honda broke the technical gaps through will be introduced. The level3 automated driving cannot be realized by only the application of AI (Artificial Intelligence), machine learning, and advanced control technologies.

Moreover, there are many tough subjects when the driving areas for automation functions are expanded from highway to city roads. The AD/ADAS vehicle has to coexist with other traffic participants in city areas. Of course, it has to avoid collision with them, even if it goes through congestion areas. However, if it indicates only passive movements following other traffic participants, it falls into dead-rock situation (continuous stop situation). The AD/ADAS vehicle has to become significantly smarter than current one in order to avoid the dead-rock situation by indicating cooperative behavior like a human. Honda expects AI and machine learning technology in order to realize the cooperative behavior of automated vehicles, and calls them "Cooperative intelligence: CI." Honda's latest research results for CI also will be introduced.