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Special Reports

Mathematical Optimization Techniques for Efficient Social Infrastructure Systems

Recent Developments in Mathematical Optimization
KOJIMA Masakazu

Mathematical Optimization Techniques Supporting Global Social Infrastructure Business
YONEZAWA Minoru / HANDA Keiichi
A wide variety of mathematical optimization techniques have been introduced into social infrastructure systems, including electric power systems, transportation systems, water supply and sewerage systems, medical care systems, and so on, to improve the efficiency of system design and operations. Global demand for the construction of social infrastructure systems applying mathematical optimization techniques has been growing in both the business and service sectors, accompanying the recent advancement of urbanization as typified by countries in the Asian region.
Toshiba has been developing systems and offering services for a wide range of customers in the field of social infrastructure systems. In response to the changing needs of global markets, we are aiming to develop mathematical optimization techniques as fundamental technologies contributing to integrated efficiency including a reduced burden on the environment, based on our experience in solving various problems.

TOPEMS$_{TM}$ Optimal Operation System to Achieve Energy Saving in Energy Supply Plants
YAMADA Toshihiro / OTSUKA Hirokazu / TSUKAHARA Hideki
Toshiba has developed the TOPEMS$_{TM}$ optimal operation system, which makes it possible to reduce operating costs and save energy in energy supply equipment such as boilers, private electricity generators, refrigerators, and so on by automatically controlling them in the optimal condition, and has been providing this system to many factories with various energy needs. TOPEMS$_{TM}$ offers the optimal operating schedule for each energy supply plant in a factory based on demand forecasts for electric power and heat (steam, cold water, and warm water). Furthermore, it supports the planning of effective facility replacement by simulating energy consumption in response to changes in the capacity and characteristics of energy supply plants.

Optimization Technologies for Operation of Complex Distribution Systems toward Smart Grid Era
MURAI Masahiko / KOSAKA Yoko / KANESHIGE Yumiko
The introduction of renewable energy sources into distribution systems complicates management of the system voltage and the operation of systems. In addition, as the average power loss of existing distribution systems is about 3%, reduction of power losses is required in order to cut emissions of greenhouse gases discharged by the consumption of fossil fuels.
Toshiba has been engaged in research and development of optimization technologies for the operation of complex distribution systems, applying mathematical optimization techniques. These optimization technologies make it possible to achieve optimal voltage regulation and minimize loss in distribution systems. Furthermore, they can contribute to the realization of stable, economical, and environmentally conscious electric power supply in the forthcoming era of mass adoption of renewable energy sources.

Next-Generation Elevator Group Control Algorithm Based on Prediction of Future Traffic Demand
YAMADA Hisashi / ASANO Norimasa / NAKAMURA Kuniko
The primary function of an elevator group control system is to manage multiple cages systematically and efficiently by allocating appropriate cages in response to hall calls to ensure the best possible service performance, in terms of both passenger conveyance throughout the entire building and the waiting time of individual passengers. The efficient allocation of cages aimed at realizing a total optimization system must therefore take into account the impacts on current and future services when scheduling each cage.
With this as a background, Toshiba Elevator and Building Systems Corporation has developed a new elevator group control algorithm that offers highly efficient service performance based on simulation of the predicted transport schedule of each cage. We have confirmed the effectiveness and efficiency of this method by means of simulations.

Railway Rolling Stock Allocation Scheduler Comparable to Experts
OTSUKI Tomoshi / AISU Hideyuki / YASUMOTO Takanori / NAKAJIMA Masayoshi
In many railway companies recently, experts have been devoting considerable time and effort to the creation of rolling stock allocation plans for certain periods and to the modification of such plans whenever railway disruptions occur.
In cooperation with Tokyo Metro Co., Ltd., Toshiba has developed a scheduler to automatically create rolling stock allocation plans comparable to those produced by experts. This scheduler makes use of our proprietary high-speed combinatorial search engine and flexible constraint expression to immediately generate an optimal plan. Moreover, an evaluation function to determine results expands the flexibility of design. Thanks to these features, our approach is expected to be applicable to a large number of railway companies.

Schedule Management Technology Making Efficient Use of Heavy Ion Radiotherapy for Treatment of Cancer
SAKAKIBARA Shizu / HANDA Keiichi / MIURA Yukio
A heavy ion radiotherapy system for the treatment of cancer is a large-scale and expensive facility, and efficient schedule management for patients and treatment processes is required so as to be able to treat as many patients as possible and facilitate the smooth work of medical staff.
Toshiba has developed a schedule management technology for a series of treatment processes, including fabrication of the holding fixture, irradiation, and so on, in order to make efficient use of heavy ion radiotherapy for the treatment of cancer. This technology makes it possible to automatically create a cyclical treatment planning table that is easy for staff to understand, and establish safety as well as efficiency in treatment. Based on this planning table, we are supporting the practical application of this technology to various procedures including reservations, rescheduling, and so on.

Feature Articles

Barge-in Tolerant Speech Recognition System
SUZUKI Kaoru / YAMAMOTO Koichi
In a barge-in speech recognition system, when the user's utterance and the system prompt overlap, recognition of the user's speech may be interfered with by echoes of the system prompt.
Toshiba has developed a speech recognition engine equipped with an echo canceller to remove such echoes from the microphone input. However, as the echo canceller is not perfect, residual echoes remain in the output signal, and the voice activity detector (VAD) to detect the section appropriate to the user's speech may misdetect a residual echo. Consequently, we have improved the VAD to ignore the same frequency components as those used by the system prompt when calculating voice activity. The results of experiments assuming vehicle application showed that the word accuracy of this system for non-barge-in speech is the same as that of the conventional system, while high word accuracy for barge-in speech is also obtained. In addition, it was verified that the tolerable volume range of the VAD is sufficiently wide compared with the sound volume of the prompt that is actually used.

Technologies for Stability of Readout Current in MONOS-Type NAND Flash Memories
FUJIKI Jun / YASUDA Naoki / MURAOKA Koichi
Toshiba has been engaged in research and development aimed at realizing a metal-oxide-nitride-oxide-silicon (MONOS)-type memory as a promising candidate for the next-generation NAND flash memory and beyond. Instability of data readout often occurs in a MONOS-type memory, caused by transient response of the channel current due to slow polarization in the high-k dielectric material that serves as a blocking layer to improve programming and erasing operations.
As a solution to reduce the transient response of channel currents, we have developed both a new blocking layer structure composed of an aluminum oxide (Al_2O_3)/silicon dioxide (SiO_2)/Al_2O_3 (hereafter referred to as "AOA") stacked blocking layer instead of the conventional Al_2O_3 single layer, and a new operation architecture comprising an intelligent reading scheme with appropriate pre-bias voltage application before reading. These technologies achieve stability of the channel current in MONOS-type memory cell transistors and highly reliable readout of data.

Modulation of High-Field Carrier Transport by Strain in Si(110) and (100) CMOSFETs
SAITOH Masumi / NUMATA Toshinori
In recent years, technology boosters, which enhance the performance of metal-oxide-semiconductor field-effect transistors (MOSFETs) without scaling of the device size, have attracted attention to the development of large-scale integrations (LSIs) with higher performance and lower power consumption. Although channel strain engineering and surface orientation engineering ((110)-plane complementary MOSFETs (CMOSFETs)) have been considered to be promising boosters, performance improvement in short-channel strained (110) MOSFETs using these technologies has not yet been fully elucidated.
Toshiba has measured drain current in short-channel (110) MOSFETs with mechanically applied strain and found that the increase in current caused by strain in short-channel devices is induced by both a change in the low-field mobility and modulation of the saturation velocity resulting from the strain. We have also demonstrated that the strained (110) MOSFETs are superior to the conventional (100) MOSFETs. The strained (110) MOSFETs are highly promising for the realization of LSIs offering higher performance and lower power consumption in future technology nodes.

Next-Generation OLED Lighting Fabricated by Solution Process
OHKA Haruhi / SHINJO Yasushi / ENOMOTO Shintaro
The organic light-emitting diode (OLED) is a surface-emitting device that is now attracting attention due to its potential as a next-generation lighting technology for uniform illumination of large areas. Although mainstream vacuum-processed OLEDs have high emission performance, introduction of the manufacturing equipment and fabrication are costly. Solution-processed OLEDs are therefore a focus of expectations for large-area surface-emitting lighting due to their high efficiency of material usage and simple fabrication process.
A high-brightness large-area white OLED panel consisting of polymer layers was demonstrated featuring a substrate with 2 μm-high stripe-shaped auxiliary electrodes and application of the meniscus printing method. Experiments on the prototype OLED panel with a large emitting area of 58 x 52 mm confirmed that it achieves a high luminance of 10,000 cd/m^2 and good luminance uniformity.

Compact Outdoor Solid-State Power Amplifier for Ku-Band Satellite Communications
MOCHIZUKI Ryo / KUWAHARA Shinichi / YAMADA Yoshio
In cooperation with Japan Broadcasting Corporation (NHK), Toshiba has developed the world's smallest 80 W-class 14-14.5 GHz outdoor solid-state power amplifier (SSPA) for Ku-band (12-18 GHz) satellite applications such as news and sports broadcasting systems, which attains a third-order intermodulation distortion (IM3) of -25 dBc.
This SSPA has a total volume of 22.8 L, achieved by improvement of the cooling structure, and can be easily carried by separating the system into two units. In addition, to enhance the gain stability, the SSPA is equipped with an adaptive gain equalizer for attenuator control according to the temperature of each field-effect transistor (FET).

C-Band 16 W-Class Internally Matched GaAs FETs
KIMURA Hideki / TAKATSUKA Shinji / TAKAGI Kazutaka
Demand for gallium arsenide field-effect transistors (GaAs FETs) offering high efficiency, high gain, and low distortion for such applications as point-to-point and point-to-multipoint microwave communication systems and satellite microwave communications has been increasing in recent years.
To meet these requirements, Toshiba has released highly efficient GaAs FETs in the X- and Ku-band frequency range (8-15 GHz). We have now developed the EL series C-band 16 W-class internally matched (IM) GaAs FETs, which achieve a linear gain of more than 11.0 dB at 8 GHz due to both improvement of the device structure of our existing X- and Ku-band FETs and optimization of the matching circuit using simulation techniques.

ESX User-Friendly Commuter Pass Issuing Machine
NITA Toshihiro / SUGIHARA Yuuji
Integrated circuit (IC) cards have been progressively replacing conventional magnetic cards in railway ticketing systems in recent years. However, the expansion of mutually available routes among multiple railway companies to take full advantage of the features of IC cards has made the issuance of commuter passes more complicated. Demand has therefore been increasing for commuter pass issuing machines with improved usability and functionality, in order to reduce the physical and mental load on operators.
As a solution to this issue, Toshiba has developed the ESX user-friendly commuter pass issuing machine with improved usability and maintenance and a longer operating life. The ESX can also automatically handle the payment of commuter pass fares in cash with the addition of a newly developed cash dispenser.

Frontiers of Research & Development