情報学を使って日本プロ野球の日程を現状よりもっと効率的にします
Applying informatics to optimize scheduling for Nippon Pro Baseball

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研究動機

2009年，鳩山首相（当時）は，今後10年間で二酸化炭素排出量を25%削減する長期目標を発表した．本研究では，情報学および離散数学における「グラフ理論」的手法をスケジューリングに応用し，エコにやさしい各種スケジュールの作成を目指す．特に日本プロ野球のスケジューリングの大幅な改良に取り組む。

Main Result

グラフ理論的手法を用いて日本プロ野球のセ・パ両リーグのスケジュールの改良に取り組み、昨年度のスケジュールと比較して69,186キロの総移動距離の削減，さらに旅行回数の24.3%の削減に成功した。今後MLB(メジャーリーグ)，NBA(バスケットボール)などのスケジュール作成への応用が期待される。

理論的背景

巡回トーナメント問題 (TTP)とは，Jリーグのように、与えられたnチームそれぞれが、他のn－1チームと本拠地(ホーム）とアウェイで1試合ずつ対戦するスケジュールを，ホーム＆アウェイゲームのバランスと，ある「公平性」のもとで，総移動距離最短のものを作成することである。TTPは有名な巡回セールスマン問題と類似である。

本研究では，TTPを応用して，グラフ上の最短距離パスを利用し，セ・パ両リーグのスケジュールを提案した（Figure 2）。この提案手法は，現行のスケジュールに比べて，総移動距離25%の改良になっている。

また，セパ交流戦のスケジュール改良にも取り組んだ(Figure 3)。

グラフ理論の日本プロ野球（NPB）スケジューリングへの応用

Team Name	最適なスケジュール(パリーグ) 1カード3試合; 主催試合(ホームゲーム)は赤								2010 日程 (km)	最適 (km)	削減比
千葉(C)	SHTFO	TFOSH	TFOSH	OSHTF	HOFST	FSTHO	TSHOF	HOFTS	23,266	16,606	28.6%
東北 (T)	HFCOS	COSHF	CHSFO	SFOCH	SHOFC	OFCSH	CHOFS	OFSCH	23,710	17,975	24.2%
北海道(H)	TCOSF	OSFTC	STFOC	FOCST	CTSOF	SOFCT	FTCSO	CSOFT	28,599	20,234	29.2%
オリックス(O)	FSHTC	HTCFS	FSCHT	CHTFS	FCTHS	THSFC	SFTCH	TCHSF	24,128	18,713	22.4%
福岡(F)	OTSCH	SCHOT	OCHTS	HTSOC	OSCTH	CTHOS	HOSTC	STCHO	33,352	21,143	36.6%
埼玉(S)	COFHT	FHTCO	HOTCF	TCFHO	TFHCO	HCOTF	OCFHT	FHTOC	20,885	19,498	6.6%

	総試合数	2010日程 (km)	削減 (km)	削減比	2010 日程 (旅行回数)	最適 (旅行回数)	削減比
パ・リーグ日程	6 x 120	153,940	114,169	25.8%	208	169	18.8%
セ・リーグ日程	6 x 120	79,067	57,836	26.8%	199	170	14.6%
交流戦	12 x 24	51,134	42,950	16.0%	108	101	6.5%
合計	1728	284,141	214,955	24.3%	515	440	14.6%

Figure 1

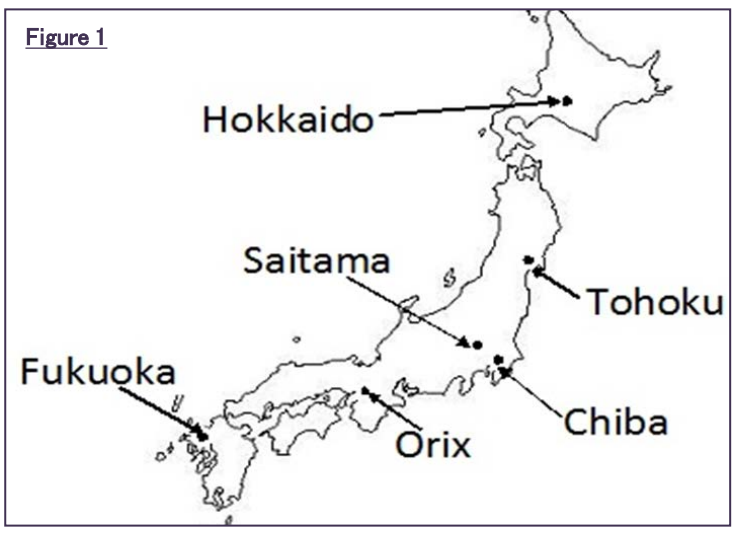


Figure 2

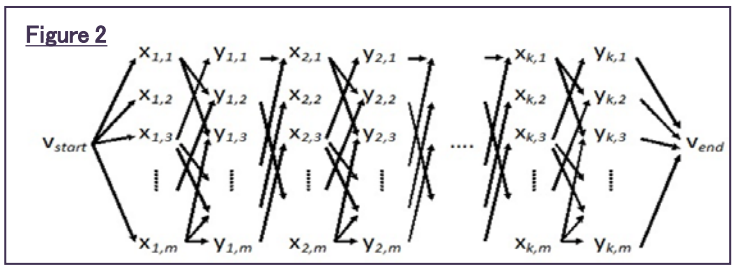
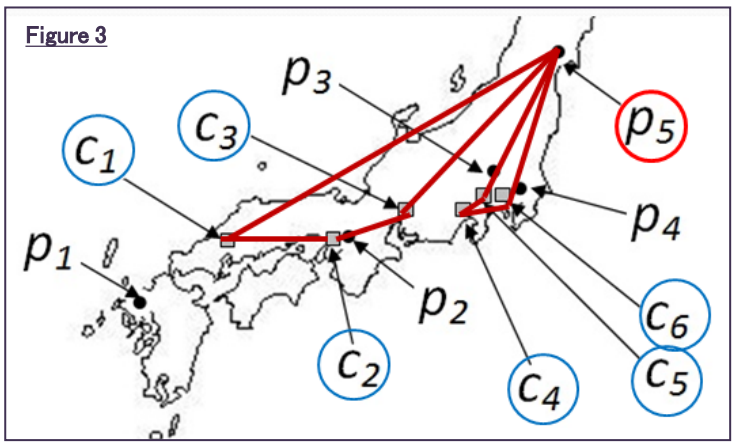


Figure 3



This research will be presented at three conferences this summer:

R. Hoshino and K. Kawarabayashi, The Inter-League Extension of the Traveling Tournament Problem and its Application to Sports Scheduling, 25th AAAI Conference on Artificial Intelligence (AAAI). San Francisco, USA, August 2011.

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Motivation

The Government of Japan has promised to reduce greenhouse gas emissions by 25% from 1990 levels by 2020. *Informatics* can help achieve this ambitious target, where combinatorial and graph-theoretic techniques are applied to scheduling optimization, leading to economic and environmental benefits.

Contribution

We have developed the *distance-optimal* schedule for the Nippon Professional Baseball (NPB) league, eliminating 69,186 kilometres of total team travel, a 24.3% reduction compared to last year's schedule. Our work represents significant potential savings in terms of time, money, and greenhouse gas emissions.

Theoretical Contributions

In the Traveling Tournament Problem (TTP), the output is a double round-robin schedule that minimizes the sum total of distances traveled by all teams as they move from city to city, subject to several natural constraints to ensure balance and fairness. The TTP is a mix of integer programming and constraint programming, and is similar to the Traveling Salesman Problem only much harder!

To optimize the NPB intra-league schedule, we develop a multi-round generalization of the TTP and present an algorithm that converts the problem to finding the shortest path in a directed graph (see Figure 2).

To optimize the NPB inter-league schedule, we develop a bipartite generalization of the TTP, and apply a clever heuristic based on minimum-weight 4-cycle-covers (see Figure 3).

Application to the NPB

Team	Optimal Intra-League Schedule (Pacific League) Each slot consists of three games; home games are marked in red								2010 NPB (km)	Optimal (km)	Potential Reduction
Chiba (C)	SHTFO	TFOSH	TFOSH	OSHTF	HOFST	FSTHO	TSHOF	HOFTS	23,266	16,606	28.6%
Tohoku (T)	HFCOS	COSHF	CHSFO	SFOCH	SHOFC	OFCSH	CHOFS	OFSCH	23,710	17,975	24.2%
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NPB Schedule Components	Total Games	2010 NPB (km)	Optimal (km)	Potential Reduction	2010 NPB (# Trips)	Optimal (# Trips)	Potential Reduction
Intra-League (PL)	6 x 120	153,940	114,169	25.8%	208	169	18.8%
Intra-League (CL)	6 x 120	79,067	57,836	26.8%	199	170	14.6%
Inter-League (PL vs. CL)	12 x 24	51,134	42,950	16.0%	108	101	6.5%
TOTAL	1728	284,141	214,955	24.3%	515	440	14.6%

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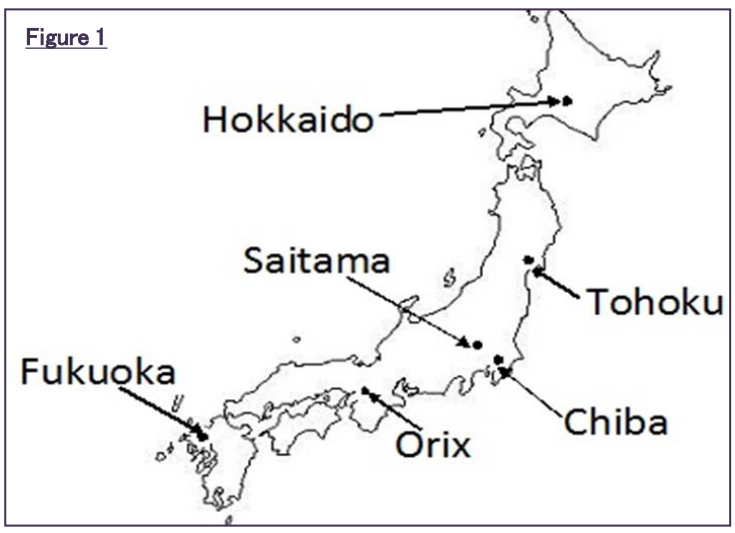
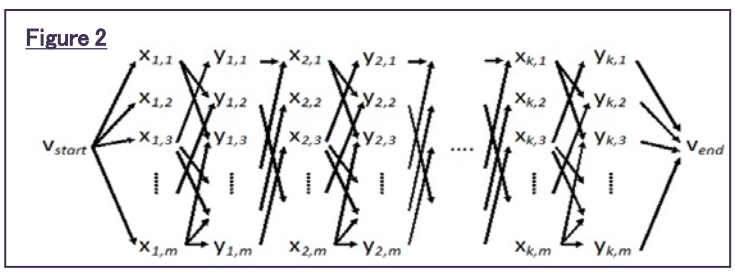


Figure 2



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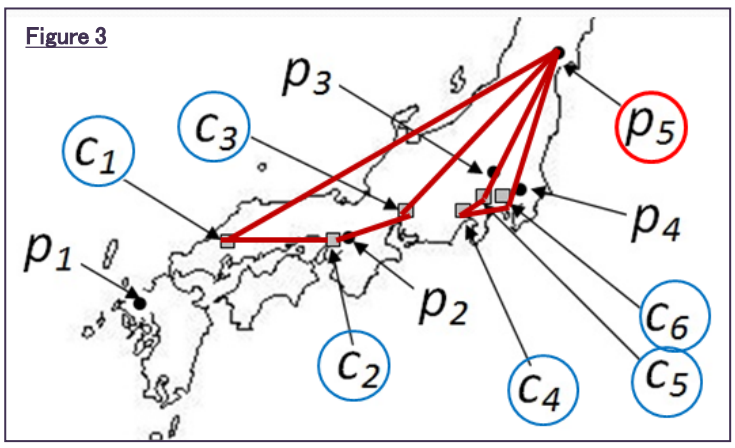

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