About the Research Priority Areas

The Nash solution (Nash, 1948) can be used to win the game, whereas the game-refinement theory (Iida et al., 2004) could be applied to obtain the sophistication of game rules, or to increase its entertainment impact.

From Opponent Modeling to Information Dynamics

In game-playing it is often assumed that the opponent has a similar (though opposite) goal and uses a similar strategy. This assumption has led to the development of the famous minimax procedure by John von Neumann in 1928. Shannon proposed in 1950 the framework of game-tree search based on the minimax and Shannon's communication theory (1948). Since the arrival of modern (fast) computers, a large number of very efficient algorithms have been developed on the basis of this procedure as well as many enhancements (such as Alpha-Beta efficiency), resulting in computers playing chess or shogi at world champion level or even better. There are, however, situations in which the minimax procedure does not lead to the best possible play because it does not use any knowledge of the actual opponent. The use of opponent models is a practice that even children can master. The game of TicTacToe provides a good illustration. At a certain age, a child learns that the game can best be played using a set of four rules (two knowledge rules and two heuristic ones). The two knowledge rules are: (1) make three-in-a-row, if you can, and (2) prevent the opponent from making three-in-a-row, if there is such a threat. The heuristic rules are: (3) take the middle square if it is unoccupied, and (4) take a corner square, if it is unoccupied. This strategy offers the child an advantage over other children who are still unaware of it. However, when time passes, all other children will have learned the strategy and games tend to end in a draw. At a certain point in time, the child will discover that if the opponent uses the strategy of the four rules, it can be exploited. The move sequence in the figure illustrates this clearly.

Cross knows that Circle adheres to the strategy of the four rules. Minimax strategy (Neumann, 1928) and Opponent-model search (Iida et al., 1993) compares.

There has been a flurry of activity at E&I dedicated to filling in the gaps and further developing the Game information model. Fundamental game patterns, game refinement, certainty of game outcome, a bevy of novel fluid mechanics experiments, and cognitive brain function experimentation are all going along full steam at E&I. The implications of this new model are far reaching with potential influence over the fields of fluid dynamics and information dynamics, and also on AI, cyber security, chaos theory, and of course gaming. The model stands to change the way we understand the nature of information, and the information of Nature.

$\text{K.E.} = \frac{1}{2}(d\xi/d\eta)^2 = \frac{1}{2}(4\eta^3)^2$

$\text{P.E.} + \text{K.E.} = \text{M.E.}\ (constant)$

$\text{P.E.} = \text{M.E.} - \frac{1}{2}(4\eta^3)^2$

at η=0, P.E.=M.E. and at η=1, P.E.=0. → M.E.=8

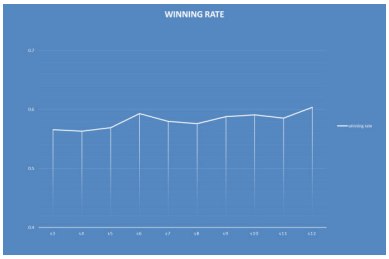
$(\text{P.E.})_{\text{Yonenaga}} = 8 - \frac{1}{2}(4\eta^3)^2.$

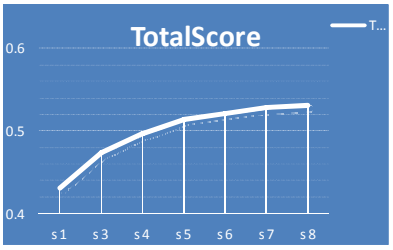
$(\text{P.E.})_{\text{Bontras}} = 50 - \frac{1}{2}(10\eta^9)^2.$

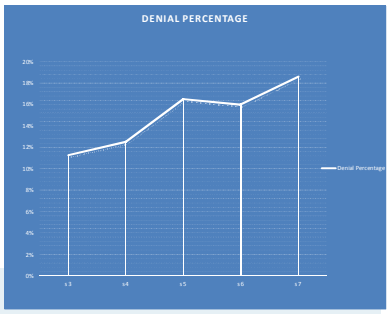
$\text{T.P.E.} = 58 - \frac{1}{2}(4\eta^3)^2 - \frac{1}{2}(10\eta^9)^2.$

Game information dynamic models (Iida et al. 2011) quantify the intellectual interaction of game players, while showing information energy.

Professor dr. Hiroyuki Iida, Director of E&I







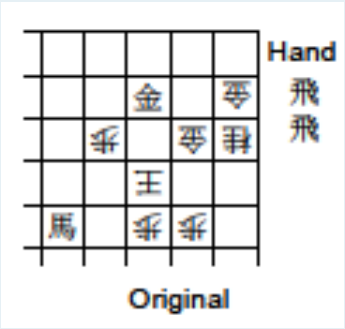
Team Intelligence: Theory and Practice

Multiple choice systems in the domain of two-person games such as chess and shogi, for example 3-Hirn (Althöfer, 1985) and consultation algorithm (Obata, 2011), have been investigated with findings that such a system can take some benefit in actual games. However, little is known about the reason why such systems work well. In this project, we consider a theoretical aspect of so-called team intelligence. We propose a mathematical representation of multiple choice systems to determine the necessary and sufficient condition of successful decision making on consensus building, i.e., voting algorithm for computer players. Then, reasonable explanation about the advantage of 3-Hirn system and the benefit of consultation algorithm are given while showing mathematical discussions.

Publication:

Y.Sato, A.Cincotti, H.Iida (2012). An Analysis of Voting Algorithm in Games, Computer Games Workshop, *ECAI 2012*, Montpellier.

K. Spoerer, T. Okaneya, K. Ikeda, H. Iida (2013). Further Investigation of 3-Member Simple Majority Voting for Chess, *Computers and Games Conference(CG2013)*, LNCS series, Springer. in press

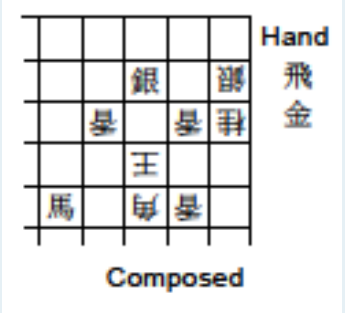


Puzzle Composition and Aesthetic Assessment

The purpose of this project is to compile, enumerate and investigate aesthetic problems in Tsume-shogi. Aesthetic problems are fun to solve. We want to know what elements of aesthetics cause emotion of human beings. To solve this problem, we are collecting data and developing a game information model for elements of Tsume-shogi. We can use this research result to advance to the next research topic. After researching the aesthetics, we will develop two systems that compose aesthetic problems and long steps problems. The systems will be used to apply our research results and meet new challenges which will surely arise along the way. In order to develop this system, we need to invent new algorithms. Although the project has had some accomplishments already, it is in what could be considered nascent stage. Our present work is active in experimentation and verification procedures which will lead us to the start.

Publication:

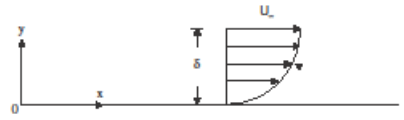
T.Ishitobi, A.Cincotti, H.Iida (2013). Shape Keeping Heuristics, Computer Games and Intelligence Workshop, *CG2013*, Yokohama.

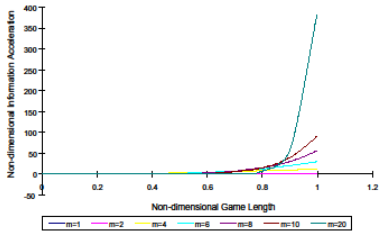


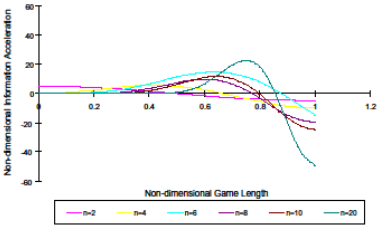
Game Information Dynamics: Theory

We proposed two different novel information dynamic models based on fluid mechanics. These models are a series of approximate solutions for the flow past a flat plate at zero incidence. It is found that the first model represents one game group where information of game outcome increases very rapidly with increasing the game length near the end and takes the full value at the end. The second model represents another game group where information gradually approaches to the full value at the end. Three game-progress patterns are identified according to information pattern in the five games, viz., balanced, seesaw and one-sided games. In a balanced game, both of the teams have no score during the game. In a seesaw game, one team leads score(s), then the other team leads score(s) and this may be repeated alternately. In a one-sided game, only one team gets score(s), but the other no score. It is suggested that the present models make it possible to discuss the information dynamics in games and/or practical problems such as projects starting from zero information and ending with full information.

Publication:
H. Iida, T. Nakagawa, K. Spoerer (2012). Game information dynamic models based on fluid mechanics, *Entertainment Computing*, Elsevier Science 3(3):89-99.



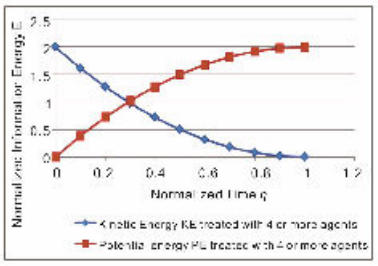


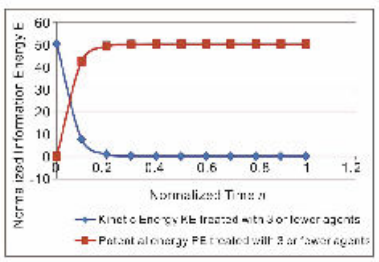


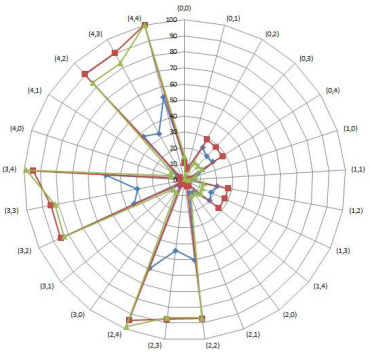
Game Information Dynamics: Application

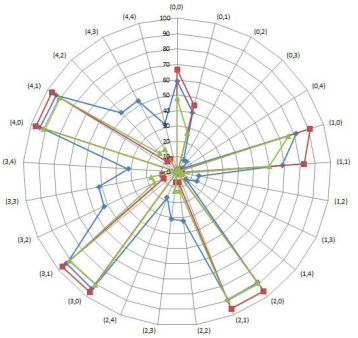
This study concerns with Hepato-Cellular Carcinoma (HCC) patients treated naturopathic agents. Patients treated with ≥4 agents survived significantly longer than patients treated with ≤3 agents. The great effect is seen in patients treated with at least 4 agents that include Cordyceps sinensis. This greater certainty of patient survival without toxic side effects is significant benefit comparing with the conventional therapy. Treatment of HCC with a regimen of ≥4 agents prepared from natural products is associated with greater certainty of patient survival in a substantial portion of patients.
The kinetic energy of certainty of patient survival decreases with increasing time, while the potential energy increases with increasing time. Total mechanical energy of patients treated with 4 or more agents is smaller than that treated with 3 or fewer agents. The kinetic energy (potential energy) of patients treated with 4 or more agents decreases (increases) more slower than the kinetic energy (potential energy) of patients treated with 3 or fewer agents.

Publication:
Open Journal of Preventive Medicine Vol.2, No.4, 490-498 (2012)
doi:10.4236/ojpm.2012.24068









Opening Book

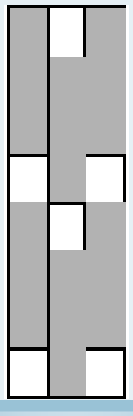
An opening book is a database of opening moves used by computer programs in games. These programs are significantly enhanced by an electronic version of an opening book. This eliminates the need for the program to calculate the best lines during the very early stage of the game, where the positions are extremely open-ended and thus computationally expensive to evaluate. As a result the computer uses considerably less resources than if it calculated the moves itself.

In this project we study the questions ”How does opening book affect game length?”, ”Is it wise for a stronger player to follow an opening book against a weaker one in tournament?”, ”How does an opening book affect game outcome?”. We try to understand the more general influence of opening book. We currently use semi-random play and tic-tac-toe.

Publication:

A. Muangkasem, K. Spoerer, H. Iida (2012). Aspects of Opening Play, *AlaSim International 2012*.

A. Muangkasem, K. Spoerer, H. Iida (2013). Aspects of Opening Play, *Asia-Pacific Journal of Information Technology and Multimedia*, vol. 2 No. 1, June 2013: 49-56.



Synchronized Games

In synchronized games players make their moves simultaneously rather than alternately. Synchronized Triomineering is the synchronized version of Triomineering, a classic two-player combinatorial game. Experimental results for small m x n boards with m+ n $\leqq$ 14 and theoretical results for the n x 7 and n x 8 boards are presented.

Synchronized Quadromineering is the synchronized version of Quadromineering, a variants of a classical two-player combinatorial game called Domineering. New theoretical results for the n x 7 and n x 11 boards are presented.

As a result, in the synchronized versions of these games there exist no zero-games (fuzzy-games), i.e., games where the winner depends exclusively on the player that makes the second (first) move. Moreover, there exists the possibility of a draw, which is impossible in a typical combinatorial game. In this project, we continue to investigate synchronized combinatorial games.

Publication selected:

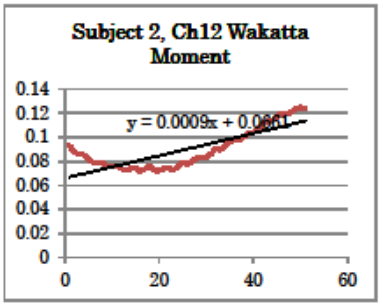
Alessandro Cincotti (2012). New Solutions for Synchronized Quadromineering, *IAENG International Journal of Applied Mathematics*, 42(2), 87-90.

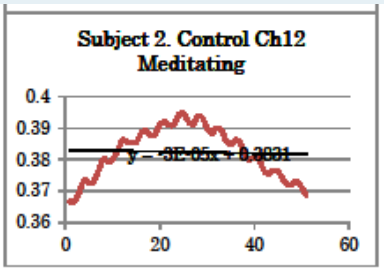
T. Cao, A. Cincotti, H. Iida (2012). New Results for Synchronized Triomineering, *International Multi-Conference of Engineers and Computer Scientists*,1482-1485.

Brain Activity Measurement

Critical positions in gaming have been defined as a moment when one senses the Information of Game Outcome prior to the game final outcome. (Iida 2010). The authors have set out to find a significant isolated cerebral signal during the critical moment when one realizes s/he is going to win (lose) a game. We devised a simple one-player game and obtained data of 11 players' brain oxygen activity using functional Near Infrared Spectroscopy (fNIRS). Our preliminary result is mixed, with a slight proclivity to decreasing oxygenation on the left side of the brain, increasing oxygenation on the right side of the brain and frontopolar areas.

Publication:
N.Nossal, N.Tsuchiyama, S.Hidaka, H.Iida (2012). fNIRS Survey of Brain Function at the Moment of Winning, *The 17th Game Programming Workshop*, IPSJ Symposium Series, 2012(6), 179-182.

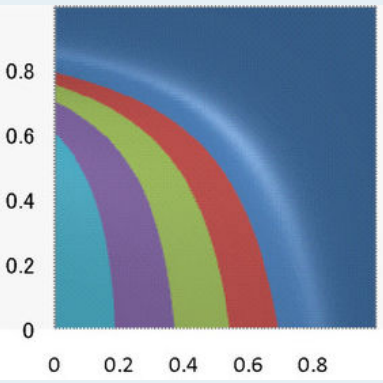


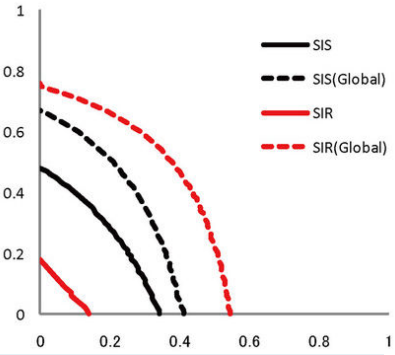


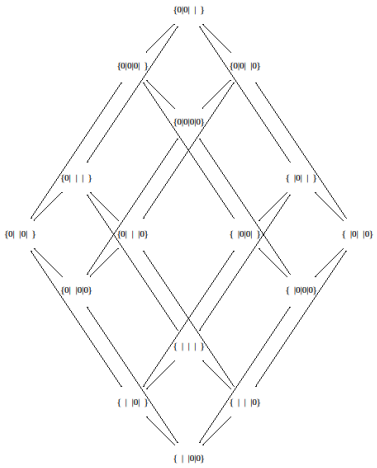
Complex Network System

In the SIR model, the infection phenomena are best understood by the number of the recovered at the final equilibrium, since all the infected are eventually recovered. We find a strong synergistic effect of prevention and quarantine under local interaction. Both measures of protection are highly effective. The total number of the recovered decreases rapidly with an increase in the protection levels. This means that a slight increase in the level of protection (by either prevention and/or quarantine) will greatly reduce the possibility of initial disease spreading. When both prevention and quarantine are combined, the number of recovered is always effectively reduced compared with sole protection alone. The effects of prevention (site) are always slightly stronger than those of quarantine (bond), when the density of sites and bonds are compared .

Publication:
Fuminori Kato, Kei-ichi Tainaka, Shogo Sone ,Satoru Morita, Hiroyuki Iida, Jin Yoshimura (20122). Combined effects of prevention and quarantine on a breakout in SIR model, 14 June *Sci. Rep.*1:10 doi: 10.1038/srep00010, 2011/06/14







The Structure of Multi-Player Games

Combinatorial game theory is a branch of mathematics devoted to studying the optimal strategy in two-player perfect information games under normal play which declares as loser the first player unable to make a legal move. When combinatorial game theory is generalized to multi-player games, the problem of coalition arises. A coalition makes it hard to have a simple game value in any additive algebraic structure. We prove that multi-player games born by day *d* forms a completely distributive lattice with respect to every partial order relation given an arbitrary coalition of players.

Publication selected:

A. Cincotti (2012). The Lattice Structure of N-player Games, *Theoretical Computer Science*, 459, 113–119.

A. Cincotti (2013). The Structure of N-Player Games Born by Day *d*, *International Multi-Conference of Engineers and Computer Scientists*, 1113-1116.

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Descriptions:

- The salary amount depends on the working hours, but is subject to the university researcher employment regulation.
- Selection of the project workers is depending on performance, capability, and knowledge basis of the applicants.
- The applicants can be either Master or Doctor course students, but should not necessarily be JAIST students. However, applications from the organizations having academic exchange agreement with JAIST is highly encouraged.

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