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Table of Contents:

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Why We Need Basic Research

Jerome I. Friedman, MIT

Human Society is at a perilous point. Science and technology have enabled us to prosper and multiply as a species. Our population is expected to cross the nine billion mark in the middle of this century and industrialization is spreading across the world as developing nations strive to improve their standard of living. Human activities are transforming the surface of the earth, but in the process we are damaging the planet's ecosystems on which we vitally depend. One of the greatest challenges we face is creating a sustainable world. At present humankind is rapidly depleting its environmental bank. Human activities are threatening the global biological and geophysical systems on which all life depends for air, food, energy and an acceptable environment. What must we do to address the critical challenges that we face at the beginning of the 21st century?

We must develop a better understanding of ecological and environmental issues, provide guidance to policy makers in these areas, and develop new technologies that abate or reduce our environmental threats. Of special importance is decreasing human-produced greenhouse gases that are entering the atmosphere and threatening to produce catastrophic global warming. If atmospheric greenhouse gas levels are allowed to go beyond a critical level, which experts say is possible by mid-century on the basis of current trends, the impacts on the planet and human society will be severe. It is likely that such a catastrophic development would result in reduced crop yields in many parts of the world; reduced supplies of fresh water; more severe storms, droughts, forest fires of increasing intensity; an increase of infectious diseases; lethal heat waves; large scale species extinction and coastal flooding that could create tens of millions of refugees. Humankind must do everything that it can to avoid these dire possibilities.

We have to develop alternative sources of clean energy that do not increase the concentration of greenhouse gases in the atmosphere. This is an especially challenging issue, because improving the standard of living of developing nations will require significant increases in their use of energy.

We have to improve the general health of the populations in all parts of the world, and in particular control the spread of infectious diseases, both old and new. A 2005 World Health Organization report suggested that global warming may already cause 150,000 deaths annually, primarily by spreading illnesses that are prevalent in hot regions of the world.

We have to provide ample clean drinking water in all parts of the world. At the present time, depletable ground water supplies are being over exploited and contaminated. About one billion people lack access to clean drinking water and roughly 40 % of the world's population regularly experience serious water shortages.

We have to eradicate hunger. It will be a formidable challenge to provide sufficient food for the rapidly growing population of the world.

To solve many of our global problems, we have to improve current technology and develop innovative new technologies that have the capability of addressing these issues. This will require greater investment in basic and applied research and in education. Not only will this help create a sustainable world, this will also have a huge impact on the economies of nations, because new technologies will give birth to new products and new industries. But it is important that we do not fall into the trap of thinking that only applied research is needed.

Why is basic research in science so important? Why not just invent radically new technologies? This approach will not work because, as we have seen from history, new, truly revolutionary technologies have been invariably based on new scientific knowledge. Even scientific research that appeared to have no possible applications has led to applications that have changed the way we live. The thesis that I want to propose today is that the major innovations of the future - -- those that will solve our greatest problems and shape the society of the future -- will require a foundation of strong basic research. Innovation <u>is</u> the key to solving the planet's problems, but basic research is the key to future innovation.

While applied research and invention play important roles in innovation, they do not in general produce the major conceptual breakthroughs that are necessary for creating radically new technologies. The limitation of focused research, or problem oriented research, becomes apparent in the following observation. If you know what you are looking for, you are limited by what you know. And as inventive as Thomas Edison was, he could not have invented the transistor, one of the most important developments of the 20th century – a development that has enabled modern technology to flower.

To demonstrate this point, it is useful to trace the history of the development of the transistor, which perhaps was the most important invention of the 20th century – an invention that is imbedded in almost all of our technology and has changed the way we live.

It started in the latter part of the 19th century, when physicists started studying the atomic spectra of various elements. The spectra that were observed consisted of discrete lines.

There was great controversy about the structure of the atom, but in 1911 Rutherford discovered the atomic nucleus in alpha particle scattering experiments and confirmed the "solar system model" of the atom that had been proposed by the Japanese physicist, Hantaro Nagaoka in1904. However there were theoretical problems with the stability of the atom in this model – it predicted that the atom would decay in about a nanosecond.

But in 1913 Bohr, using the quantum ideas of Planck and Einstein, developed a semi-classical model of the atom based on a quantization of the electron orbit. It accounted for the discrete spectra of hydrogen and established a new paradigm for the stability of the atom. It was, however, only an approximate theory. Then between 1925 and 1926 Heisenberg and Schrodinger developed quantum mechanics. This was a complete non-relativistic theory of the hydrogen atom that explained the measurements of the spectral lines of hydrogen.

In 1928 Bloch applied the full machinery of quantum mechanics to the problem of electrical conduction in solids, spearheading the development of the modern theory of solids between 1928 and 1933. Then in 1929 Schottky and others pointed to the existence of electron "holes" in the valence-band structure of semiconductors, uncovering the mechanism of the behavior of semiconductors.

These advances culminated in the invention of the transistor in 1947 when Bardeen and Brattain took out a patent for a transistor; and Schockley applied for a patent for the transistor effect and a transistor amplifier. And by1955, transistors began replacing tubes. Then in 1959, the integrated circuit was invented by Noyce and Kilby; and the microchip was the beginning of a new technological revolution.

What this example demonstrates is how curiosity driven basic research established the foundations of the technological revolution created by the invention of the transistor. It is ironic that quantum mechanics, one of most abstruse conceptual frameworks in physics - one that was developed to explain the structure of the atom - lies at the foundation of some of our most important technological developments. It contributed to the development of technologies that gave us world wide communication, computers with their applications to all phases of modern life, lasers with many diverse uses, consumer electronics, atomic clocks, and superconductors - just to mention a few. In modern industrial nations, quantum mechanics probably lies at the basis of a sizable fraction of the gross national product.

Although I have emphasized basic research, the above examples demonstrate that all types of research are required. Applied research, and product development have also played crucial roles in the development of the transistor. New technologies clearly cannot be created without a synthesis of all three. And often the boundaries between these types of research get blurred. Applied research sometimes leads to important basic knowledge. And very often, applied research is an essential component of basic research because existing instrumentation is not adequate for pursuing a particular area of scientific research and new types of technology have to be developed. These new technologies often lead to spin-offs, which have broader applications in society.

For example, accelerators were invented to study the interactions of sub-atomic particles, and now various types of accelerators are used for such diverse applications as cancer therapy and the fabrication of semiconductors and microchips. Synchrotron light sources are being used to design new drugs, study the structure of viruses and study new types of materials. Other examples are the World wide web, the Global Positioning System, nuclear medicine, and diagnostic tools such as magnetic resonance imaging, positron emission tomography, and computerized axial tomography.

Economists have studied the impact of research on the Gross National Product or on other measures of wealth or well being. This can be seen as a measure of the economic impact of the innovations derived from such research. Economists have estimated that 1/2 to 2/3 of the economic growth of developed nations is science based while there is uncertainty in these numbers, there seems to be no disagreement that the impact is huge and the past investment in research has paid for itself many times over.

But who will support basic research in the future? Industry, which supported a significant amount in the past, generally does not do so any longer. Fierce global competition has put enormous economic pressures on industrial corporations. Private industry will make R&D investments that are expected to pay off within 5 to 7 years, but it won't make the 20 to 30 year investments that are necessary to create entirely new industries. Long- term investments in Research & Development have been cut as firms have merged and down-sized. Monopolistic companies that used to do long-term R&D, such as AT&T and IBM, have seen their industries become highly competitive. To compete they have largely withdrawn from supporting basic research.

I remember discussing this matter with a friend who is a prominent scientist in a corporation that did significant basic research in the past. I asked him where his firm got its ideas for future developments. He said, "We don't do research - we search." But this approach requires someone to do the research. Who will do it? It is clear that basic research must rely primarily on government support, either national or local.

This is also being seen in another trend. Patents are a strong indicator of innovation. A study prepared in 1997 found strong evidence that publicly financed scientific research plays a large role in the breakthroughs of industrial innovation in the United States. The study, prepared for the National Science Foundation by a private research group, found that 73% of the main science papers cited by American industrial patents in two prior years were based on domestic and foreign research financed by government or nonprofit agencies. Such publicly financed science, the study concluded, has turned into a "fundamental pillar" of industrial advance. This shows the close connection between national science budgets and the economy. It also points to the importance of establishing good bridges between universities, government, and industrial laboratories.

You might wonder why I am stressing the importance of basic research in this talk when applied research and product development also play important roles in innovation. I am making this point because of all the types of research, basic research is the most vulnerable.

Basic research is an activity that seeks scientific knowledge for its own sake without thought of practical ends. It is inherently a risky enterprise. Neither its outcome nor its applications can be predicted in advance.

And as was shown in my example of the development of the transistor there are often long delays in the applications that arise from basic research. Because of these factors, the importance of basic research is often not well understood by the public and by political leaders. When some new important scientific result is announced and the public asks how it will benefit society, the scientists involved often don't have a clue as to how to answer this question. In general, they cannot make any promises about its future applications.

If we can't make any promises about the success or applications of basic research, how do we communicate its importance and relevance to the public and political leaders? They and political leaders want to hear arguments about applications, economic growth, and competitiveness.

We can make such arguments; but if they want examples, we can only talk about the past, because we are not able to make specific promises about the future. But we can use history as a guide. We can tell them that throughout history, advances in scientific knowledge have resulted in revolutions in technology that have improved the standard of living and changed our way of life. Although, direct benefits to society from the applications of basic research generally require a number of decades, they do come. After all, electricity and magnetism were laboratory curiosities in the early 1800's but did not become a factor in people's lives until more than a half of century later. But the applications of electricity and magnetism have had a dramatic impact on the way we live. The history of the transistor demonstrates the same long delay and huge pay-off to society.

I would like to summarize the key elements needed for sustaining major innovation in the future:

* There must be strong support for basic, applied, and engineering research from government and industry -- basic research requires special attention.
* We need an educational system that encourages and nurtures creativity.

There should be a great emphasis on inquiry & intellectual independence.
* Centers of Research (Universities, Industry, Government) should strongly support the research of young scientists and engineers and be willing to take risks.

* We need to maintain strong Research Universities. They are the source of cutting-edge research and the future scientific work force.

* We must maintain good bridges between Universities, Government and Industrial Laboratories.

* We must keep the public informed about science and technology in order to maintain its support and minimize technological backlash.

In conclusion, to address and reduce the serious problems that afflict the world we need the efforts of science, applied science and engineering. To achieve our goals, we need to expand our base of knowledge and need to educate our young people so they can utilize and further expand this knowledge. It is my conviction that ample investment in science and technology is an absolute necessity to develop the innovations we will need for the future. Innovation is the key to the future and research is the key to future innovation. Only by making such investments can nations protect the environment, ensure future improvements in their standard of living and stimulate economic growth.

Economics for Physicists and Ecologists

Gorga, Carmine

Abstract - The lack of communication among physicists, ecologists, and economists can be mostly attributed to the type of mathematics economists use as well as their study of flows of money rather than stocks of real wealth. This paper presents the essential characteristics of a new framework of economic analysis, Concordian economics, which uses standard mathematics and geometry and observes stocks as well as flows of real and monetary wealth. This paper thus attempts to build bridges among the relative disciplines, because it is becoming increasingly clear that vexing problems of human and natural ecology can be solved only through collaboration among economists, physicists, and ecologists.
Keywords – *economics, stocks, monetary wealth*

1. INTRODUCTION

There is a well-known lack of communication among physicists, ecologists, and economists. Using a new framework of economic analysis, Concordian economics [1], a system of thought that results from the relentless application of age-old tools of logic and epistemology to mainstream economic theory, this paper attempts to build bridges among the various disciplines so that lines of communication can be opened and solutions can be found to today's vexing problems of economics and ecology. Physicists, being practical problem solvers, and ecologists, being deeply concerned about the status quo, might join together in this mission to let economics reach the splendor of its full potential.

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2. PROBLEM STATEMENT

Lack of communication among physicists, ecologists, and economists is rooted in the practice of economists, who have developed their own specialized form of mathematics to analyze economic problems; and have reduced the number of admissible problems to those that exist in the market at the moment of the exchange. Thus they analyze only flows, not stocks of wealth; and they observe only money, not real resources. In particular, physicists have long remarked that modern economic theory cannot possibly be a fit description of the reality because, among other reasons, it is a closed system without inlets and outlets [2]. Ecologists, on their part, never seem to engage economists because, among other reasons, while they are mainly concerned with stocks of real wealth, economists are mainly concerned with flows of money [3].

3. FINDINGS

Three essential findings of Concordian economics are reported here with the assistance of modern mathematics and geometry: stocks are separated from flows of wealth; the real economy is separated from the monetary economy; these two parts of the economic process are then joined together through the introduction of the legal and institutional economy into the equations.
Through painstaking analysis (Gorga 2002, 23-158) [4], real wealth (RW) is defined as stocks of consumer goods (CG), plus capital goods (KG) and goods hoarded (GH). The fundamental model of production (P) is formulated as follows (*Ibid.,* 38, 313):

$$P = CG + KG + GH$$
$$IA = P - GH$$
$$IA = (CG + KG)$$

where IA = Investment Assets (until sold).

Monetary wealth (MW) is defined as the sum of all financial instruments used to purchase CG, KG, and GH as well as other financial instruments:

corresponding equations form the model of consumption (*Ibid.,* 318). The legal economy is defined as the value of all rights of ownership over real and monetary wealth: corresponding equations form the model of distribution (*Ibid.,* 316). Since the structure of these models is self-similar, they are omitted here.

The three systems of equations form an equivalence [5], the equivalence of production to distribution and to consumption. They describe the same entity, the economic process, from three strictly interconnected points of view. In more detail, this equivalence refers to the production of all real wealth; the distribution of ownership rights over both monetary and real wealth; and consumption (or expenditure) of monetary instruments to purchase real wealth. This equivalence can be more easily observed with the assistance of geometry. Thus, using established protocols, it is possible to synthesize the above three systems of equations into one unit represented by the following diagram:

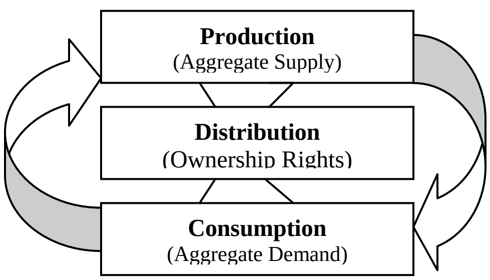

***Figure* 1. The Economic Process**

Figure 1 represents the economic process at the moment of the exchange—as in mainstream economics, but with an enlarged focus. The unit of account can be the economy of an individual person, an individual firm, the local, the national, or the world economy. Figure 1 reads as follows: When goods and services pass from producers to consumers, monetary instruments of a corresponding value pass from consumers to producers. For the exchange to occur, the transactors must be the owners of both money and real wealth. Then, one cycle of the economic process is completed. As can be seen, Concordian economics is wholly relational and inherently dynamic. This second characteristic becomes more explicit if one sees each rectangle of Figure 1 as a Poincaré section. In Figure 1 the economic process is observed at one static moment in time.

There are three approaches for a comprehensive study of the dynamics of the economic process. One is the analytical/mathematical approach. It yields the following

generalized system of equations:

$$p^{\cdot} = fp(p,d,c)$$
$$d^{\cdot} = fd(p,d,c)$$
$$c^{\cdot} = fc(p,d,c),$$

where $p^{\cdot}$ = rate of change in the production of real wealth, $d^{\cdot}$ = rate of change in the pattern of distribution of ownership rights over real and monetary wealth, and $c^{\cdot}$ = rate of change in the consumption or expenditure of monetary wealth.

The second approach for the study of the dynamics of the economic process is the historical/latitudinal one. This study calls for following the dynamic transformation of the system, ideally from the beginning of time till today. Starting from flows of real and monetary wealth one obtains a result that is very familiar to modern physicists, a strange attractor or a Lorenz attractor, see, e.g., Thompson (1986, 228) [6]. A few cycles are reproduced here:

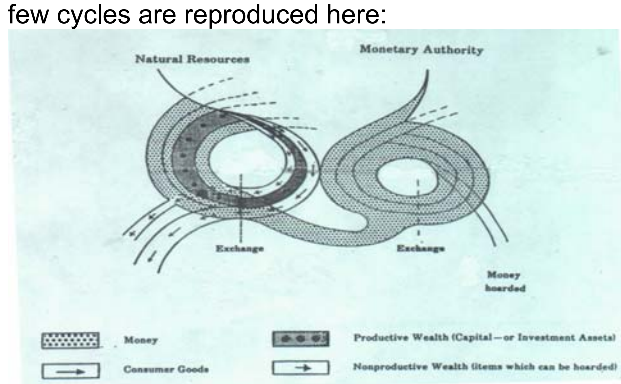

***Figure* 2. Flows of Values**

With Figure 2, we are not only within the economic process—an area that is a black box to mainstream economics [7]; we have also found the inlets and outlets requested by physicists. The inlets are flows of real and monetary wealth; the outlets are consumer goods, goods hoarded, and money hoarded. It is only capital goods and money to purchase real wealth that remain permanently within the system. The flows of the legal/institutional economy are fully inserted in this construction: They are invisibly present at the moment of the exchange. In order to buy and sell wealth one has forever had to have ownership of that wealth. Indeed, to think of the extreme complexity of the reactions that occur within the economic system, the reader is encouraged to mentally close the two halves of Figure 2 thus creating the image of a torus or a cyclotron. In the reality of daily life, stocks and flows of real and monetary values do not organize themselves into neat patterns, but tend to intermingle and interact with each other.

The third approach is the longitudinal/programmatic one, through which one obtains an external view of the economic system as a whole. This is a new perspective that yields a simplified understanding of other characteristics of the economic system. This mode of analysis can be briefly described as follows: If the economic system were composed of three identical, synchronous, and compenetrating spheres (obtained by rotating each rectangle of Figure 1 at ever increasing speed and in all directions about their geometric center), the system would leave behind only one trajectory as an indication of its dynamics. This line—whatever its pattern—would indicate that the three spheres were in continuous equilibrium with each other. This is not the case in economics: As Mandelbrot (1983, 1) [8] is fond of saying, "Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in straight lines." Can economic systems be expected to be represented by perfect solids? To say the least, the trajectory of aggregate values of monetary wealth (MW) can be expected to soon leave the initial condition of equilibrium (0,0,0) and, spurred by the facility with which monetary instruments can be produced, grow at a faster rate than the trajectory of values of real wealth (RW). Also, the spheres representing the pattern of distribution of values of ownership rights over real *and* monetary wealth, which are known to remain rather static over time, can be conflated into two overlapping straight lines to be identified as DO. Then, over time, eliminating all short and long term, cyclical, random, or aperiodic loops, breaks, and turns, the system as a whole can be expected to leave behind idealized traces of motion as in the following figure:

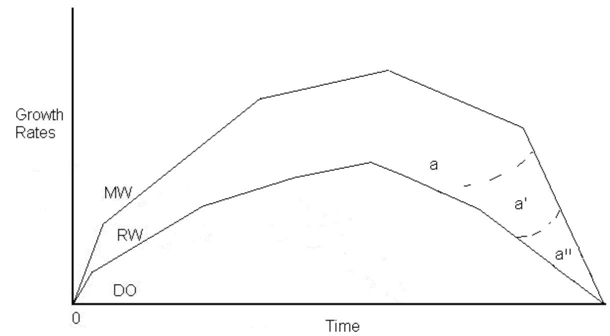

***Figure 3*. Trajectories of the System as a Whole.**

The distance between RW and MW will eventually yield the mathematical measurement of the "bubble". Current efforts to identify the bubble are especially intense [9]; physicists adept at chaos theory have been investigating this issue for quite some time [10]. Area "a"—with its alternative sub-areas a' and a"—attempts to describe the condition of disequilibrium (the bubble) that so often develops between monetary and real wealth and suggests that the smaller this area, the smaller the loss of real income over time. How to close the gap between the real and the monetary economy in the shortest possible time is clearly a problem of control, namely, a problem of economic policy—the problem of creating a just and sustainable economy.

4. CONCLUSION

There is much work to be done. As can be seen, the intellectual framework is mostly done; it is the practical work that is all to be done. This is the work of organizing the data in accordance with the categories of thought specified above; this is the work of analyzing the data with the assistance of modern tools of scientific research. The tempi for the performance of this work can be enormously speeded up if physicists, ecologists, and economists assiduously work together [11].

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[10] See much work done at the Santa Fe Institute.

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Brief Biographical Sketch of the Author

Carmine Gorga is a former Fulbright scholar and the recipient of a Council of Europe Scholarship for his dissertation on ”The Political Thought of Louis D. Brandeis.” Using age-old principles of logic and epistemology, in a book and a series of papers Dr. Gorga has transformed the linear world of economic theory into a relational discipline in which everything is related to everything else—internally as well as externally. He was assisted in this endeavor by many people, notably for twenty-seven years by Professor Franco Modigliani, a Nobel laureate in economics at MIT. The resulting work, *The Economic Process: An Instantaneous Non-Newtonian Picture,* was published in 2002. For reviews, see http://www.carmine-gorga.us/id18.htm. During the last few years, Mr. Gorga has concentrated his attention on matters of methodology for the reunification of the sciences.

Landmark Detection and Position Correction of Autonomous Mobile Robots Using a Linear Array of Three Ultrasonic Sensors

Vela Nunez, Marina; Ohya, Akihisa

Abstract - This paper presents a methodology to enable a mobile robot to automatically correct its odometry errors while it is navigating and detects landmarks in the environment. Those landmarks are defined a priori to the navigation process, since the map is available beforehand. The robot is able to know whether the detected object is a landmark or not, extracting the necessary information from the range data. The range data is obtained from 3 ultrasonic sensors placed in the right side of the robot. The experiments carried out showed that: the robot was able to detect a landmark on the environment, identify it with regard to the landmark in environmental map and recover its position errors. Furthermore, the robots are able to distinguish a landmark from other object.

Keywords: *Mobile robots, ultrasonic sensors, indoor environment, landmark identification, position correction*

1. Introduction

Odometry is the most widely used navigation method for mobile robot positioning. It is well known that odometry provides good short-term accuracy, is inexpensive, and allows very high sampling rates. However, the fundamental idea of odometry is the integration of incremental motion information over time, which leads inevitably to the accumulation of errors. Particularly, the accumulation of orientation errors will cause large position errors which increase proportionally with the distance traveled by the robot.[2][1][8]. To overcome this problem, a solution to the robot sense its surrounding and detect landmarks for position error correction with its external sensors was proposed by: [10][11][12][13]. For such reason, in our previous researches [3] [4][5] and in the present work our interest of searching for such algorithm. In a previous research a methodology was implemented in a robot's platform that used only one sensor. In this methodology the robot corrected its position at the sensing areas of the landmarks. The sensing areas are determined in advance because the robot couldn't know whether the detected object is a landmark or not.[3] For this reason, in this paper we presented a new methodology, an approach to solve one of the basic problems of accumulate odometry errors that is "Position Correction of Autonomous Mobile Robot". The robot should be able to detect the landmarks with the ultrasonic sensors and then corrects its position. In this methodology the robot senses the environment continuously while is navigating. Since the robot is able to distinguish landmarks and other objects, extracting the necessary information from the reflection of the range data. The range data is obtained from 3 ultrasonic sensors, placed on the right side of the robot. (Figure 1) The straight walls are supposed to be the landmarks in this research.

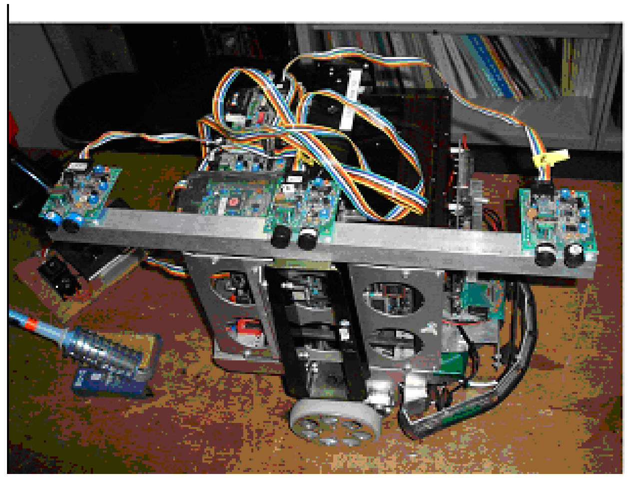

Figure 1: ***"Yamabico" special configuration: three ultrasonic sensors placed on its right side.***

2. Position Correction System using three Ultrasonic Sensors

2.1 Position correction procedures

To enable a mobile robot to know *when* it should correct its position, we propose a method for detection of the landmarks. It consists on reflect the sonar sensor obtained from the three ultrasonic sensors, then is possible to identify whether these data came from a landmark or not. If so, the detected landmark is compare with the environmental map knowing in advance. If the robot detects other kind of object, just ignore it. By other object the authors mean all the objects of the given environment which do not directly affect the algorithm, i.e. not the ones which serve as landmark. As soon as the robot knows that it had detected a landmark and identify which landmark was found, and if is needed correct its position.
The advantage with this method is that since the robot will have three consecutive sensor data it can recognize immediately if it has found a landmark and if it should correct its position.
Using this method the robot should be able to:

- Detect a number of landmarks.
- Distinguish between a landmark and other object.
- Identify which landmark it had found.
- Recover its position errors.

2.1.1 Environment definition

In this method, in order to define the environment to the robot, we represented it by vectors. (Figure 2). These vectors represented the landmark on the environment. Each side of the vector will have a defined area according with its orientation in the x-axis. The right side of a vector represented the emphoccupied area of a landmark. By occupied area the author mean the side of the landmark that will not be used as reference of navigation. The left side represents the *free area* of a landmark, the one that the robot sense and use as a reference of its actual position and if needed correct its position. The path is also specified to the robot a priori of navigation.

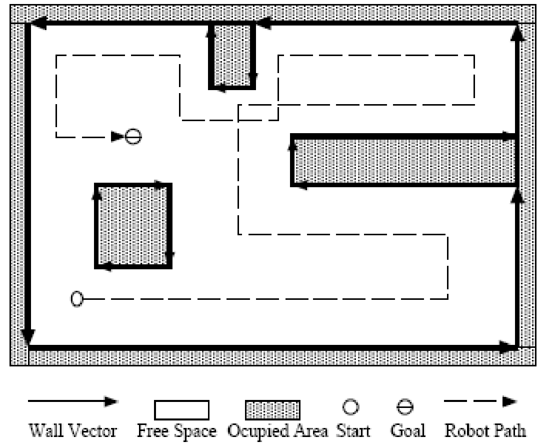

Figure 2: Definition of the map of the environment. The landmarks are defined to the robot as vectors.

2.1.2 Extracting a landmark from others objects on the environment

In order to enable the robot to distinguish a landmark from the other objects in the environment, we developed the next procedure in where the robot has to sense the environment continiuosly while it is navigating through it enviroemnte especify a priori, the robot will get the range data information from three ultrasonic sensors represented by(r1, r2, r3). The three lengths will be subtract as (r1 - r2) and (r2 - r3) then both results are compared, if those are different it mean that the robot has found a object, if the results were the same it mean that the robot had found a landmark.(Figures 3 and 4).

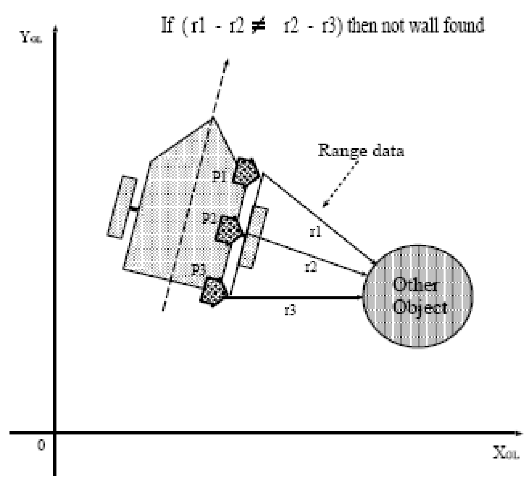

Figure 3: The robot deduces that it did not find a wall when the 2 (length differences) are different.

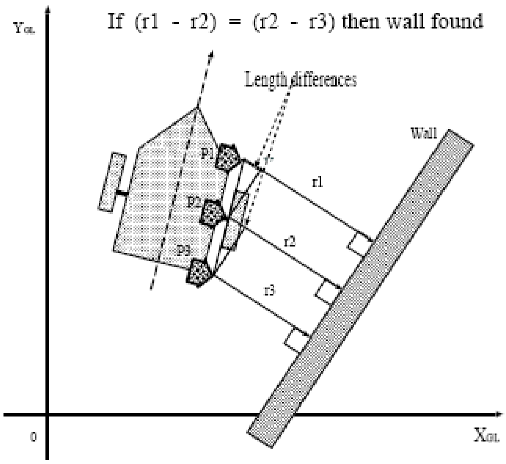

Figure 4: The robot deduces that it found a wall when the 2 (length differences) are igual.

2.1.3 Estimated Reflection Points

The ultrasonic sensor provides useful information for recognizing the environment. One of its characteristics is that its reflection is in vertical direction. It shows, for example, the angle of the landmark.[6][7]. Knowing this information it is possible to estimate the reflection of the points on the environment. In our system, once the robot detects a landmark in the environment it will estimate the reflected points (*R*1,*R*3). (Figure 5).
The procedure for the estimated reflection points will be as follows:
The range data information is obtained from the two ultrasonic sensors (*r*1, *r*3). Supposing that the two ultrasonic sensors of the robot are located on *P*1(*x*1,*y*1),*P*3(*x*3,*y*3) and the position of the robot is(*xabs*, *yabs*,□*abs*). Then is possible to obtain the two reflected points if we estimate the vectors $\overrightarrow{P_1R_1}$ and $\overrightarrow{P_3R_3}$ like this:

$$\overrightarrow{P_nR_n} = \begin{pmatrix} x_n \\ y_n \end{pmatrix} + \begin{pmatrix} r_n \cos\phi \\ r_n \sin\phi \end{pmatrix} \quad (1)$$

Where:
rn: Represent the length obtained for the range data information. *xn*,*yn*: Position of the robot.
Then the direction of the ultrasonic reflection is denotes
by the angle □and 0 degree is set on the direction of xaxis.
Where:

$$\phi = \theta + th \quad (2)$$

□will be estimated as:

$$\cos\phi = \frac{r_1 - r_2}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}} \quad (3)$$

th: Orientation of the robot on x-axis.

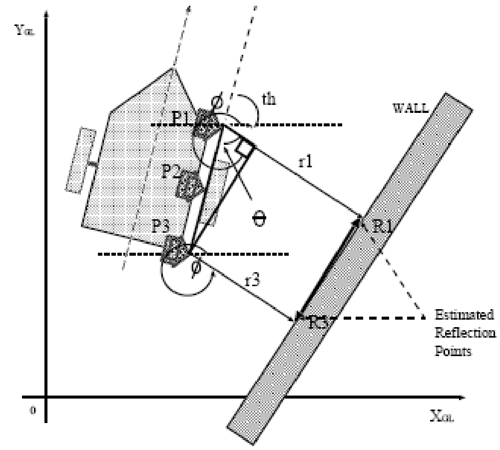

Figure 5: Estimation of the two reflected points (R1,R3).

2.1.4 Selection of a landmark from the environmental map

In order to enable the robot to match the detected landmark with the one in the map, we propose an algorithm in which the robot will compare the orientation on x-axis of the detected landmark with the orientation of each landmark in the map.(Figure 6). When the robot finds that a landmark on the map has the same orientation of the detected landmark, then it estimates *D*1 and *D*2. These are the distances between those two landmarks. If *D*1 and *D*2 are inside of the proposed threshold therefore, the robot knows that it found a landmark and it is able to identify which landmark it has found from the environment.(Figure 7).

2.1.5 Position Correction

In this section we present a specific procedure for reducing the odometry errors. In which the robot will compare the angle of the detected landmark q*calc* with the angle of the landmark on the map □*wall* , in case that those were different a new angle will be estimated like this: □*error* = (□*wall* - □*calc*) that it is the error angle. The robot position using odometry is represented as(*xabs*, *yabs*,□*abs*). Then the robot will rotate it orientation to the new angle obtained from □*new* =(□*abs*+□*error*). (Figure 8).

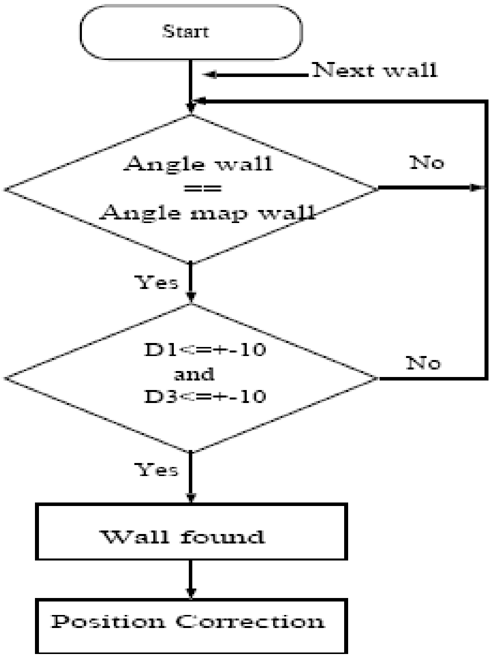

Figure 6: Procedure for landmark detection.

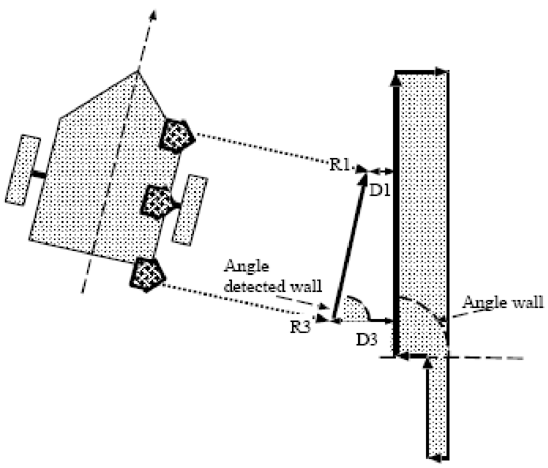

Figure 7: Identifying a landmark on the environment.

Once that, □*new* was obtained, the new position (*xnew*, *ynew*) of the robot will be estimated as:

$$\begin{pmatrix} X_{new} \\ Y_{new} \end{pmatrix} = \begin{pmatrix} x_{abs} \\ y_{abs} \end{pmatrix} + \begin{pmatrix} \cos(\theta_{wall} + 90) \\ \sin(\theta_{wall} + 90) \end{pmatrix} (D) \quad (4)$$

Where:
D: The standard distance between detected wall and real wall.
*D*1,*D*2: Distance to the wall from the Estimated Reflection Points (*R*1,*R*3).
Then the robot will match its actual position to (x_{new}, y_{new}, θ_{new}).(Figure 9)

3. System Implementation

- The algorithm was implemented on the "Yamabico robot" special platform.
- The robotic platform has a sensor array, consisting of 3 ultrasonic sensors, mounted on the right side of the robot at a distance of 20 cm between them. The range of the sensor is ±15 to 20 degrees within 300 to 500 cm.(Figure 1).

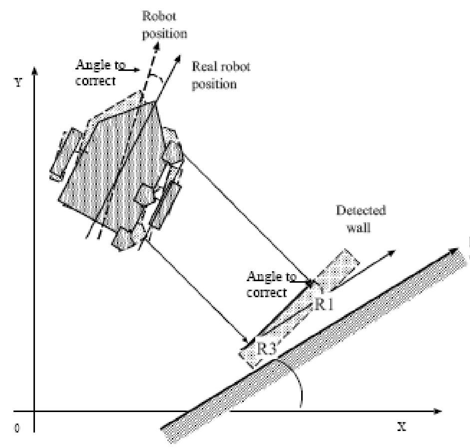

Figure 8: Shows when the robots rotates its orientation tothe correct one

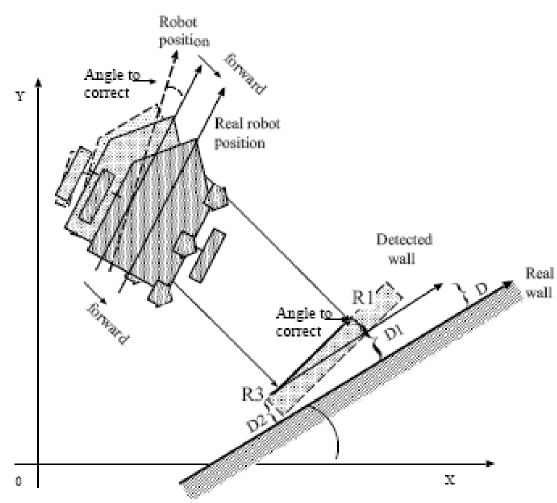

Figure 9: Shows when the robots match its position to the new corrected one.

4. Experiments and Results

A set of experiments were carried out to verify the effectiveness of the implemented algorithms.
The goal of these experiments is to verify if the robot is able to:

- Detects the landmark in the environment while it is navigating
- Correct its odometry errors of navigation,
- Distinguish a landmark from other objects placed in the environment.

4.1 Description of the experiment No. 1

The experiment consisted on run the robot in cw direction following a square path around reference walls. The robot should navigate on this path 10 times.

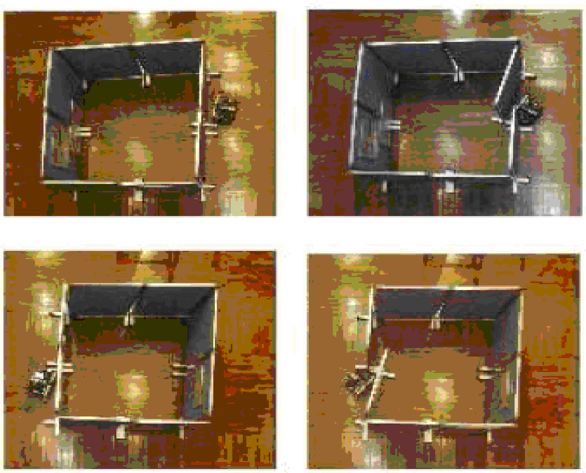

Figure 10: Top view of the experimental environment. Representation of the behavior of the robot when it runs on the square path using only Odometry.

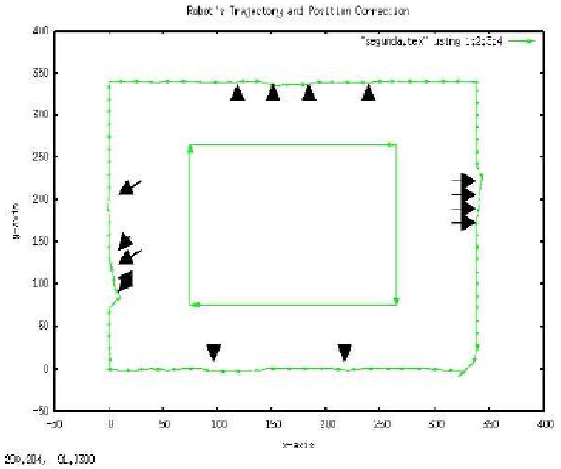

Figure 12: Representation of the behavior of the robot when it runs on the square path and correct is odometry errors.

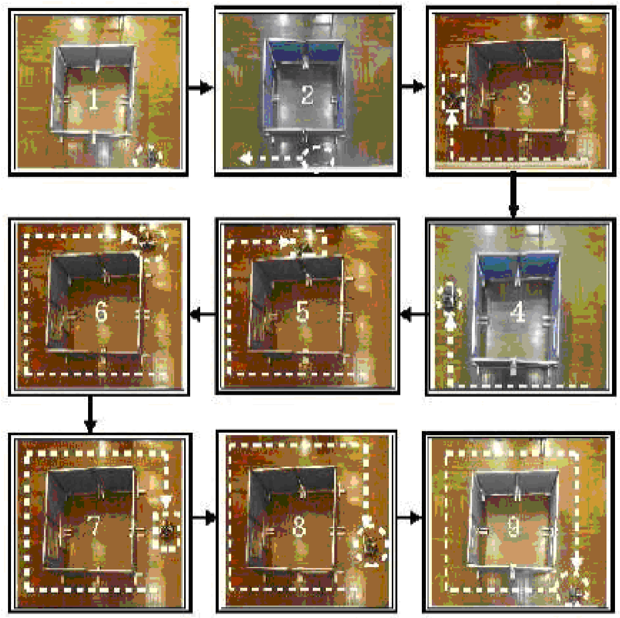

Figure 11: Top view of the experimental environment. Representation of the behavior of the robot when it run on the square path using our system of "Position Correction".

1. The robot runs using only running commands (odometry).
2. The robot runs using our system of "Position Correction".

- The landmarks information is stored in the memory of the robot.
- Experiments were conducted in front of the Intelligent Robot laboratory University of Tsukuba.
- The testing environment for experiment No.1 consisted of 4 artificial walls formed a square with the length of its sides of 2X2m. Figure 10 and 11 show the example of the testing environment.
- The robot path was specified a priori.

4.2 Results of the experiment No. 1

1. As a result of the first part of the experiment, the robot did not succeed in completing the 10 rounds, the robot lost its position and in the 4 round it hits one of the walls. (Figure 10.)
2. As a result of the second part of the experiment, the robot successfully recovered its position, identified correctly several landmarks while navigating through the environment with a map available a priori. It finished 10 complete rounds ending nearly at the same start position.

The representation of the behavior of the robot when it run on the square path using our system of "Position Correction" is presented in (Figure 11). The flow is going from step no.1 to no.9.

- *Dashed lines*: shows the behavior of the robot during the experiment.
- *Dashed circle*: shows the correct position of the robot.
- *Dashed square*: shows when the robot corrects its position.

The start and end robot's position are showed in the steps no.1 and no.9. As these robot's positions are almost the same place, it could be deduced that the robot's trajectory was corrected successfully.
In order to have a real data information of the behavior of the robot when it is navigating around the specified square and correct its position, we obtain the data information of the current position of the robot each 1 sec. The position correction was done by the robot each 2 sec and it was run at a velocity of 15cm/sec. It is shown it in the detailed view in the graphic. (Figure 12)In this graphic the position correction is pointed with the black arrows.

4.3 Description of the experiment No.2

This experimentwas performed in order to test if the robot is able to distinguish a landmark from others objects.

- The robot has information of a wall with a length of 2m before the navigation process. In the environment were placed: One robot.($robot_{ob\,j}$), a wall of 95cm.($wall_{ob\,j}$), a tube of diameter of 21.5cm.($tube_{ob\,j}$).
- The ($robot_{ob\,j}$) and ($tube_{ob\,j}$) represents the other objects on the environment.(Figure 13)
- The robot was run in a straight path of 2m at a velocity of 10cm/s, its start position was at 75cm from the wall.
- • Current information of robot's position each 1 sec and estimate reflected points each 2 sec was obtained.

4.4 Results of the experiment No. 2

The detailed view of the graphic on figure14 shows the results of this experiment.

- The *points* are the robot raveling also the small points on the bigger line are the estimated reflected points.
- The *vectors* are the detected walls.
- The *line* the wall specified to the robot a priori

The results on the graphic show that: when the robot detected other object in the environment it ignores it. In the experiment the robot ignores the first object ($robot_{ob\,j}$) and the second ($tube_{ob\,j}$) but, it successes on detected the($wall_{ob\,j}$). It can be deduced in the graphic for the estimates reflected points and detected wall vectors.
These results show that the robot is able to distinguish a landmark from others objects using the system proposed here.

5. Conclusion

In this paper we presented a strategy for correction the odometrical errors of the autonomous robot navigating in indoor environments with the map available a priori. The robotic platform has a sensor array, consisting of 3 ultrasonic sensors, mounted on the right side of the robot. A set of experiments were carried out to verify the effectiveness of the implemented system. As a result, the robotwas able to detect landmarks, define which landmark was found in the environment, and recover from odometry errors using an environmental map specified a priori. Further more, the robot was able to distinguish a landmark from other objects.

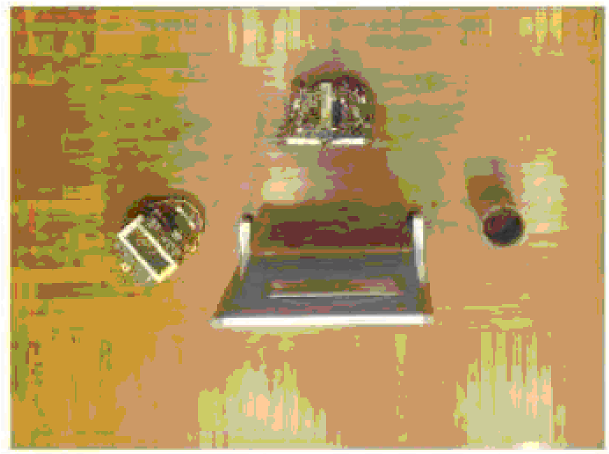

Figure 13: The top view of the experimental environment No.2 using a wall and other objects different than a wall.

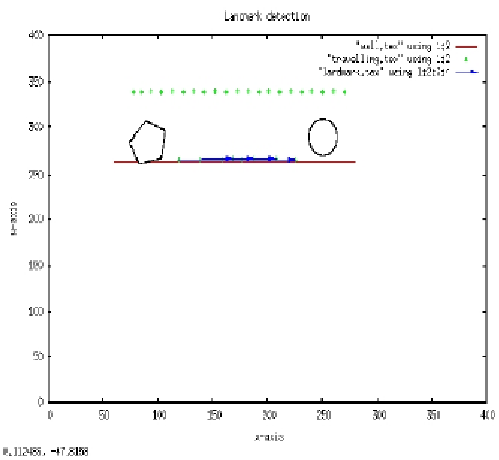

Figure 14: The experimental result after the robot travel in a staight path with a wall and two other objects.

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Human Computer Interaction Based on Cognitive Modeling

Fujita, Hamido; Hakura, Jun; Kurematu, Masaki

Abstract - This paper is presenting a progress a development results on Virtual intelligent interface based on human facial and voice recognition. We this is new challenge for sensing the user emotional space and interact with it. It is part of the cognitive spatial design needed to have the mentality of the designer been part of the system recognition. This is experimental built prototype. We think that the practices reported in this work contribute to integrate (corporate) the cognitive intention of the designer with the knowledge of the system. The architect can use these design practices to inhale the emotional practices into the design using such experiment.
Keywords – *cognitive modeling, facial recognition, emotional sensing*

1 Introduction

People interact with digital technologies through touch manipulation and gesture interaction is increasingly being embodied. People move through environments embedded with digital artifacts, and interact with and through technologies in new ways. This act as collaboration in design, and specify the architecture as collaborative cognitive design process. This participate in generative and evolutionary techniques in architecture [10]. There are digital spaces that participate in architectural design in such digital world that involve people to interact through its space [19],[2].

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The architect can use these design practices to inhale the emotional practices into the design using such experiment. Minsky[12][22] describes a possible architecture for organizing agents into a flexible, human-like Society of Mind. Rather than seeking a best way to organize agents, their architecture supports multiple ‘ways to think’, each a different architectural configuration of collaborative agents. Holland [8] identifies three different kinds of distribution of cognitive process’ across people, across representation, and across cultures. Socially distributed cognition focuses on the role that a group of people have in thinking and knowing and on the phenomena that emerge as a result of these social interactions. Cognitive process makes use of external as well internal representations. These external representations are things such as notes, entries in logbooks, and other information artifacts. It is a metaphoric representation, collected from different dimensional representation, (i.e., disciplines), collectively to enact for example Miyazawa Kenji and revive him through such conceptual cognitive representation. Psychology, linguistics, computer science, and philosophy, collectively can lead to cognitive science disciplines. Cognitive Psychology [14][1], contributes to understand human thought from an individual perspective.

We project an evolutionary conceptual framework through the following parts of Miyazawa Kenji project. We present the main four parts of the project. We show our technology on the interaction between human and virtual system representing the cognitive mental model of other human subject.

In this paper, we are using such case study to bridge these cognitive evolutionaries issues and incorporated it in the design of intelligent human centric computing that can mimic a specific human cognitive behavior. Based on this cognitive modal we can reason on real human interactive behavior for spatial design. The rest of this paper is organized, to show the major part in this case study.

In Section 2, we discuss the example of presenting certain human cognitive model. We have used Miyazawa Kenji cognitive mode. In Sec. 3 we present part 1 of the system, that will create the emotional feature of Kenji system as virtual world. In Sec. 4 we present part 2 of the system, that collect human user cognitive interaction and mental behavior based on Kenji Style reasoning and other knowledge related to common sense reasoning. In Sec. 5 we preset part 3 of the system, that related to voice emotional recognition. In Sec. 6 we deal with Part 4, that initiate the scenarios and responses to the user in role act style to the cognitive behavior of the user state. In Sec. 7 we present conclusions.

2 Cognitive Human observation issues

In this section we are outlining the Kenji Style case study. As mentioned in the introduction that we have selected Kenji Miyazawa(MK) to be the virtual model of our experiment on intelligent human interaction cognitive based conceptual model. http://www.kenji-world.net/english/who/who.html;this link gives an overview about who is Kenji. Such cognitive behavior reasoning system interacts with human user based on cognizing-based reasoning, and factorized through, based on MK cognitive studies. Though we use MK, however this experiment can be extended to other cognitive human model. The outline of Kenji System can be referenced in [6]. The way in which we use our mind becomes the way in which we use our body and the attitudes of mind so that to create its own manifestation in the function of the muscles that implements deliberately the concessions behavior behind it. Previous or old thoughts (from Aristotle to Darwin) saw facial expressions as the result of internal emotional states. Facial expressions were seen as pre-warning of emotional responses on others.Kenji style is the emotional voice and facial animation that virtual MK is able to speak through in role act to the user. These are the extracted cognitive feature reasoned templates. As stated in the introduction, we need to construct creatively and physiologically Kenji style featured by his personality implicitly hidden within his scripts and from scholars who have acquaintance on his personality reflected through his published artwork. This style is constructed from collected data by testing actual person act with some knowledge on Kenji scripts. The analysis data have been classified according to six emotional modes of EKMAN. We use such style of reasoning to label and understand on how to use the gesture. We have selected scripts from Kenji artwork. The analysis is based on cognitive feature extraction referenced on reading of above-mentioned Kenji scripts (1) by specialist in Kenji literature and his art pieces. Also, the same has been done by: (2) reading observation analysis on non-expert people, (i.e., general Japanese people). This all is in reference to Kenji own utterance, cognitive thinking extraction, referenced by customs, habits and other self-based extracted personality related to different views analysis. The resulted patterns or templates reflect what we called *Kenji Style*. Kenji style has been captured using the above-mentioned two case studies approaches. More details on Kenji style reasoning model can be referenced to [Fujita, 2006].

3 Emotion Estimation from Facial Expressions of Users

Part 1 of Kenji System presents the hologram, it is as shown in Figure 2. The total image of Kenji Hologram is on Figure 4, image_2. The other image(1) snapshots are taken while Kenji is talking through the emotional templates that are created in real time by the Emotion processor (We called it *KANJO* processor, *KANJO* means emotion in Japanese language). The OutputVideo program make automatic connection to realtime generated animation emotional template. KANJO processor (Figure 1) is synchronizing the MAYA images that is generating in real-time animated facial images, and synchronized through KServer (Figure 1), and the emotional sound file extracted Kenji text (refer to: Figure 5), all this is synchronized through KNAJO processor. All this; is referenced as Part_1 in our system.

Figure 1-1. KANJO processor

Figure 3-2. KENJI-Engine Server
Figure 1. Virtual Engine component

The details of the software development (Part_1) are omitted for space and technological securities issues related reasons. You can reference to demos on this application by reference to [9] or the link (http://www.fujita.soft.iwate-pu.ac.jp/prof_dir/issam/others/KenjiOnly.wmv). Please notice that all output is done in real time. This section will be reference again in Sec.5, and related to creating facial images in harmony with the contents of the spoken text.

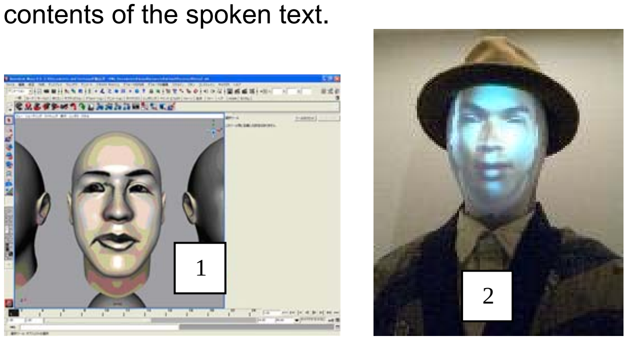

Figure 2. Shows part 1 of the hologram

4 Emotion Estimation from Facial Expressions of Users

In this section, we preset part 2 of Virtual Kenji system, that to make the interaction between Kenji and human user, to achieve the conceptual cognition engagement with a user, the system is required to react to emotional states of the user. Emotional states of the user can be perceived through emotional signs exhibited in several modalities, such as words, vocal features, and gestures, and recognized collectively through situated reasoning. Gestures are known as one of the essential modalities to perceive the emotional states of the user. Among the gestures, facial expressions afford a great deal of emotional information in human natural communications. In proportion to the importance, there have been a lot of studies concerning facial expressions are conducted not only in psychology and philosophy, but also in computer science. One of the most popular approaches to automatic facial expression analysis is relying on the Facial Action Coding System (FACS), (for FACS, Ekmann and Friesen, 1975[4]; for a survey of the literature see, Pantic [18]. The FACS uses the combinations of movements of facial parts, named Action Units (AUs). Namely, detecting the AUs is the main subject of the approaches relying on the FACS. The AUs' are defined as typical results of movements of facial parts in facial expressions, such as "left eyebrow up" and so on. Thus, they are apt to focus on the static images of the facial expressions, and require the completion of the expressions. Namely, they do not fully utilize the dynamic aspects of the facial expressions. This would result in the misleading at on the reasoning about the situation: "What triggers the facial expression?"

To know the emotional states of the user together with the exact timing of their appearance is one of the important requirements to the conceptual cognition. For this aim, we have introduced a linear system identification approach to the facial expression analysis [7]. The approach is able to fully utilize the dynamic aspects of facial expressions.

The approach assumes that the movements of the facial feature points are the consequence of the facial muscles modeled as linear systems with several modes. The modes of the system correspond to the represented emotions, and each identified mode of the system can estimate the movements of the facial feature points in expressing the emotion. As shown in Figure 3, the differences of the estimated movements and actual movements are used to detect the emotional expressions. While we are planning to merge the approach with the FACS approach, yet at the current stage, this section concentrates on the system identification approach. The rest of the section is assigned to the following four topics: Face and feature points' detection's method; Facial expression database realizing system identification approach; Emotion estimation with facial expression database, and an experimental results showing that the proposed method can detect the six basic emotional expressions, i.e., happiness, surprise, sadness, fear, anger, and disgust, with their exact starting points.

4.1. A Face and facial feature points detection method

In contrast to our previous results on this project [6][7]that require a motion capture system to detect face and facial feature points, we have adopted Active Appearance Model (AAM) (Cootes et. al., 1998) to raise the availability of our system. While there is a defect in the accuracy, there are several advantages in this change such as free from markers (used in motion capture systems), and availabilities of the device and needed real time processing. The AAM is a statistical model/method to detect deformable objects in images. It makes a statistical model of the shapes and appearances from training images with manually added feature points. When applied to the novel image, it finds parameters to adapt the model to the novel image by means of an optimization method. Today's computational advances enable the method to be processed in real time so that it can be applied to object tracking tasks. The points on the facial images in Figure 4 are automatically detected by the implemented AAM system.

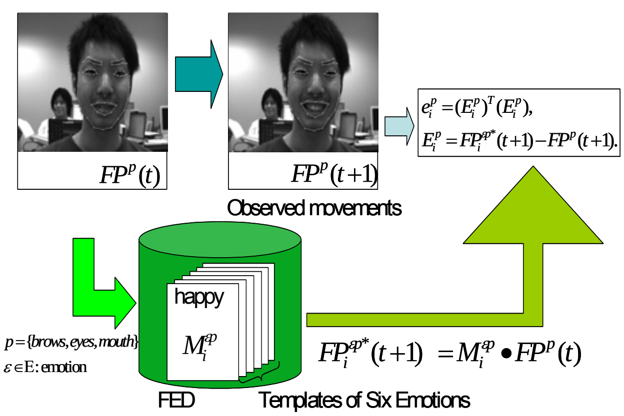

Figure 3. System Identification Approach to Facial Expression Analysis.

4.2. Facial Expression Database (FED)

Facial expressions in this study are considered as the results of movements of facial feature points. Facial feature points are the points that are needed to estimate the target emotional expressions by observing the movements of these points. The movements of the feature points are assumed to be caused by a set of systems as in the Facial Score [15]. The system identification method, i.e., LSM: Least-Square Method is adopted to identify the systems. A face is divided into roughly three parts: eye brows, eyes, and mouth. Each part is assumed to contain its own emotional signals. The results of the identification for each part would be the six transition matrixes; each of those can estimate the movements of the facial feature points for particular emotional facial expressions. The acquired knowledge is collected as a database, called Facial Expression Database (FED).

To extract typical movements of the facial feature points that express the particular emotion, we should collect facial expressions that represent the particular emotion. For this aim, subjects who have trained to express the six emotions act on each emotion for several times, and the movements at that time are labeled as an emotion. As mentioned above, the movements are represented as result of the system's output. The system has some modes; initially, the duration is assumed to be a mode. A merging algorithm of the modes reduces the number of the modes. The similar movements are considered as results of the system in the same mode. Namely, each mode expresses an emotional category. The detail of the algorithm is described in [6]. As the results of applying the algorithm, each mode corresponds to the most typical movements of these points to express an emotion. For example, when there exists N durations labeled as "fear", the modes that representing fear are described as follows:

$$\mathbf{M}^{\mathbf{fear}} = \{\mathrm{M}^{\mathbf{brows}}, \mathrm{M}^{\mathbf{eyes}}, \mathrm{M}^{\mathbf{mouth}}\},$$

$$\mathrm{M}^{p} = \{M_i^{p} \mid 1 \le i \le m, i \in I, 1 \le m \le N\}. \quad (1)$$

where, $p = \{brows, eyes, mouth\}$, I denotes a set of positive integers. M^p is obtained for each of the six emotions.

The modes are represented as the transition matrixes. Namely, every facial feature point can be estimated by using the matrixes. Let eye brows requires six feature points (three points for each brow) at time t denoted as $FP^p(t) = (px_1, py_1, px_2, py_2, \cdots, px_6, py_6)^T$, where px_i and py_i are the x and y coordinate of i-th feature point respectively. Then, the points at the next time step can be estimated by the following equation:

$$FP_i^{p*}(t+1) = M_i^p \bullet FP^p(t) \quad (2)$$

where, p* means that it is the estimated value. Note that M_i^p is a 12 x 12 matrix in this example. Note also that every estimation value is calculated by the actual value of the facial points. The estimation process compares the error between actual and estimated values of the facial points for every mode, part, and emotion. The following describes our method to do estimation with the modes setting.

4.3. emotion estimation with facial expression database

As mentioned in the previous section, FED provides system identifiers of the systems that control the facial feature points. Therefore, emotional estimation from the facial expression with FED uses these identifiers to know to what emotional categories the presented facial expression belongs. The presented facial expressions can be detected as the movements of the facial feature points with a vision system and the AAM, so that $FP^p(t)$ in Equation (2) are available at every time step. Every identifier estimates $FP_i^{p*}(t+1)$ at the next time step through Equation (2). These estimated points are compared with the actually observed points at t+1, and then we can calculate the error e_i^p:

$$e_i^p = (E_i^p)^T (E_i^p),$$
$$E_i^p = FP_i^{p*}(t+1) - FP^p(t+1). \quad (3)$$

Note that e_i^p is a scalar value, and E_i^p is a vector. Then, according to Equation (1), we have $|M^p|(=m)$ errors for each facial part with respect to each emotional category. To determine which emotion is observed, we have to cumulate the error values of each part. We simply employ the minimum value for the aim, because the identifier with the minimum error itself implies that the emotion is detected:

$$e^p = \min_i \{e_i^p\} \quad (4)$$

Namely, we have now error vectors Δ_e consist of three elements, i.e., on eyebrows, eyes, and mouth, for each emotion:

$$\Delta_e = (e^{brows}, e^{eyes}, e^{mouth}),$$
$$e \in \{\text{joy, sadness, anger, disgust, fear, surprise}\} \quad (5)$$

While the error vector can be used as differently, we simply add the errors. Then, the error is used to estimate the expressed emotions: Here we simply set an empirically obtained threshold to each error. Namely, the emotion with the estimation error below the threshold is considered as the expressed emotions.

4.4. An Experiment on detecting emotions

We have implemented the AAM by means of the aam-api [24] coupled with OpenCV library (Open Computer Vision Library). The frame rate of the camera is approximately 20 frames per second.

An experiment to check basic detective abilities of the proposed approach is conducted. For this aim, only a subject who acts on six emotions according to the FACS is assumed to be the target person. Thus, the training data for AAM and the FED is prepared only for the subject. After construction of the AAM and the FED, another sequence of the actions is observed. In the observation phase, emotion estimation process works in real time, and the results are sent to the conceptual cognition engine in response to the facial expressions of the subject. To confirm the above-mentioned abilities of the approach, the subject acts on the six emotions in the following order: happy, surprise, anger, disgust, sadness, and fear. The frames corresponding to the facial expressions are listed in Table 1.

The result of the experiment is depicted in Figure 6. Figure 6(a) shows the transitions of sums of the difference between estimated movements of the feature points and the actual movements of the points, i.e., estimation error, observed in each frame. Namely, the estimations by means of the modes (matrices) corresponds to the six emotions are compared with the actual movements of the feature points. Therefore, the lower error value means that the corresponding emotional facial expression is observed. Comparing Figure 4 with Table 1 reveals interesting facts. The error values rapidly decrease at the beginning of each act, and in most cases, continues decreasing until the facial expression becomes the typical one that can be recognized with FACS. Figure 4(b) is the actual sequence of the facial expression expressing "Happy" from beginning to the end. It means that the proposed method is able to detect the very beginning of the facial expressions. It is very important for our aim, i.e., construction of conceptual cognition system, because the system should know what makes the user having that emotion. Although some emotions, disgust and happy, and fear and sadness, seem hard to distinguished by the proposed method, the other emotions are detectable with the method. The undistinguished emotional expressions are sometimes very hard to identify even by the human when forced to identify it only from the facial expression. We are planning to merge and/or analyze the information from the other modalities, i.e., voice (as explained in the following Section), situation, and so on, to overcome this issue.

Acted Emotional Facial Expression	Frames
Happy	51 to 105
Surprise	131 to 170
Anger	222 to 268
Disgust	310 to 346
Sadness	394 to 430
Fear	535 to 569

Table 1. Frames and Acted Emotional Facial Expression.

5. Emotional Voice recognition

This Section resembles what we call as part_3 of Virtual Kenji System. In our system reference to Figure 2 (emotionally generated facial images), the corresponding text with emotional features (represented as templates) generated by the system and spoken by Kenji system as shown in Figure 5, are been synchronized to create the total cognitive real image interface for talking person with cognitive personality specialized as Kenji. The facial movement of the lips has been (real time) synchronized by interface (LipSync mentioned on the references), which is API (application program interface) with MAYA application. However, the templates generated on in Figure 5 used conventional rules that we revised as in the following.

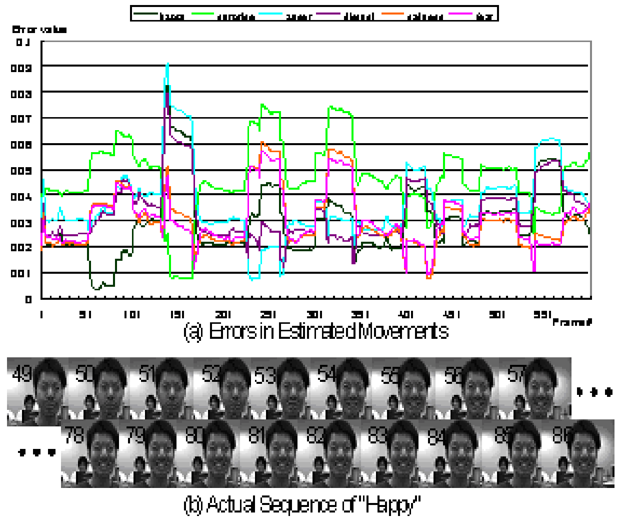

Figure 4. Result for Estimating Acted Emotions.

Researchers use discriminant rules to estimate emotion in human speech in general [16]. First, researchers record human utterance that participants speak certain phrases emotionally in role act, like actor or actress. Second, researchers extract sound features, for example power and fundamental frequency using frequency analysis and get mean and maximum value of these features. Finally, they make discriminant rules from these features using machine-learning methods, for example decision tree and artificial neural network. These rules depend on recorded data. The set of such rules are not the same among different systems. Therefore, the correctness rate is not high.. We think it is necessary to improve such method. For the voice emotional recognition system, we propose three methodological steps to improve the referenced method.

More details in this section have been omitted due to space. However, it should be clear that the voice emotional characteristics have been computed as part of the interface to have consistent emotional integration with intention.

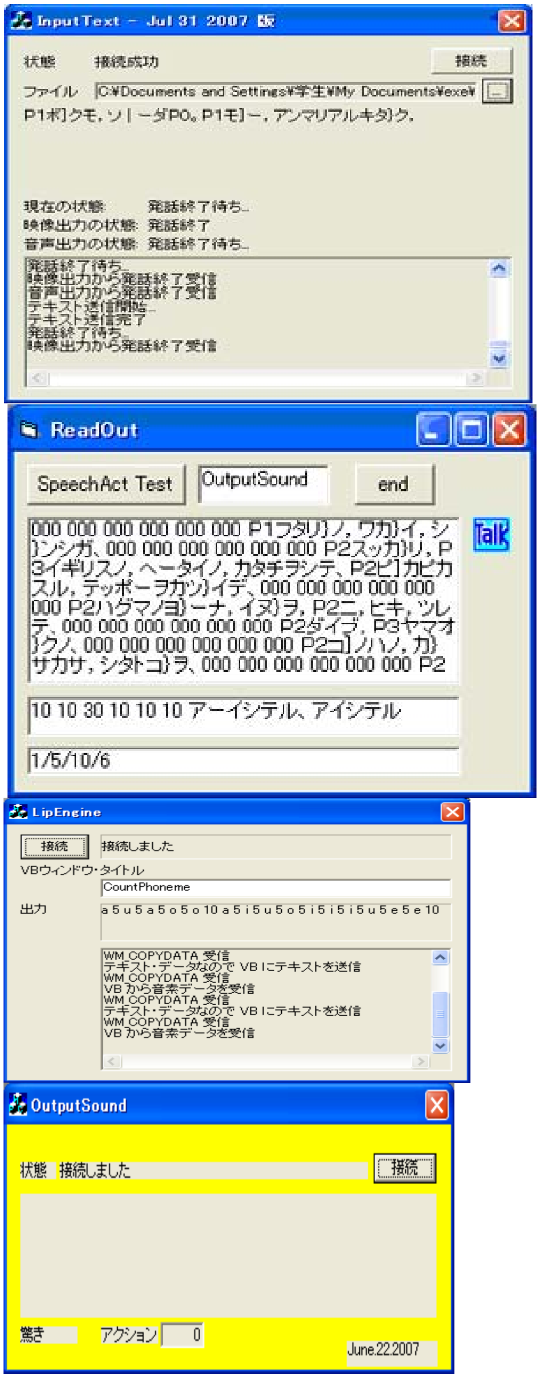

Figure 5. Shows the screens of the Input text window, and readout window processors.

6 Cognitive Scenario generation according to human cognitive state

We explain the part 4 of the system. How to make system act with the user according to the situation, what type of possible scenario or knowledge that the system can provide to the user? These issues should be reflected on memory structure and situation computing. The User cognitive states been examined and analyzed using Part 2 of the system. The user engagement with Kenji system is computed using Sec.4 that analyze the facial expression of the user to examine the degree of user engagement the system, which conclude if the user is interesting in the current created scenario or not interesting. Actively engaged or disconnected. There are four states, which the system concludes to reach; according to the decision taken through the facial analysis of users. Also, this is the same for voice emotional recognition as well. So, we have a view on facial analysis state (using Sec. 4), and view on voice analysis state (using Sec. 5). These two views are integrated to create the cognitive state of user engagement with Virtual Kenji system. We have created several scenarios that prepared according to the expertise in Kenji cognitive style views. The implementation on these scenarios has been assembled in what we called Emotional Processor shown in Fig. 6

Box (1) in Figure.6 shows emotion estimated by facial emotion estimation module.

Box (2) in Figure.6 shows emotion estimated by speech emotion estimation module.

Blank in box (1) and box (2) shows that there is not estimated emotion.

Box (3) in figure.X.3 shows an output of the emotion determiner. In figure.X.3, this Japanese character shows that happy/joyful is much stronger than other emotions. Therefore, Kenji system expresses default output emotion.

Box (4) in figure.6 shows an output emotion generated by the emotion determiner

Also other views have been prepared according to several situations, that been classified according what is called as 1st imprecision [20]. We are experimenting a tool named as digital physiognomy from www.uniphiz.com to test user physiological emotional states before they engaged with KENJI so that to create emotional 1st impression model.

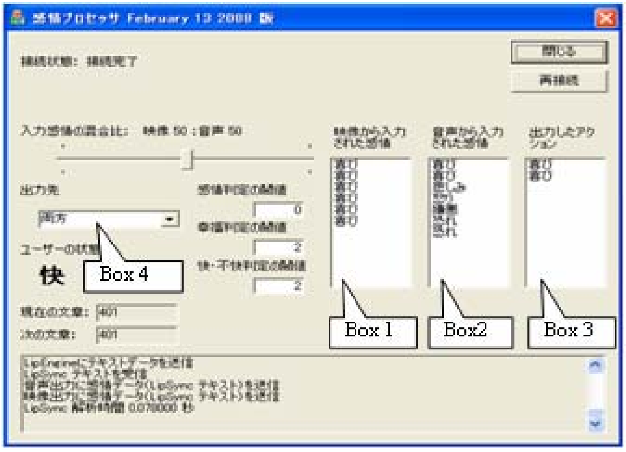

Figure 6. Show the Emotion Processor window

According to the type of the user face, we created a scenario that Kenji virtual model can interact. These systematic guidelines are to simplify the best engagement between the human user the virtual system.

Though the experiment is to have the system, be Kenji and the user is general user who has certain knowledge and interest on such famous writer. We think the system can be useful for HCI design to complex creative artwork, like architecture design, where the user nonverbal communication work in hand with to stimulate the designer thinking for best harmony with system and user cognitive thinking mutually, with emotional integration of the design.

The templates mentioned in Sec.4 and Sec.5 should include a mechanism to include situations, and user metal background ontological views (vast views: culture views, and mental view and spontaneous views). We human our intellectual communication is not bounded by templates. Though we use them in learning and adapting our self through them, but we modify them for best performance. For example, we learn templates on driving skills by theory and practices. But on road, we modify these templates to match it to our behavior and cognitive mental performance. Such adaptability is related to the best adjustment that our body system and condition can fit into to create the best harmony that we think such driving performance is best. For the same human, driving style (templates) in downtown Cairo is not as driving style in downtown Tokyo. Looking into the contents of cognitive actions, we notice different patterns, between the proposed virtual system and human user in terms of perceiving a certain space. The spatial space relationship cognitive integration between human and virtual system is essential to best harmony in communication. These issues can be reflected into the Architecture design, when the integration of spatial space in design is essential to evaluate the whole layout of the architecture.

7. Conclusions

We think the development of new interactive environment (like virtual Kenji system) can employ user interface with spatial cognition integration. This can contribute to reduce the load of mental visual reasoning. Such anecdotic view based on spatial cognition is essential for architecture design.

This research has other objective in bridging the complexity of communication between human and computer in design issues solutions.

We are now integrating with this system colors and music to be part of the presentation to reflect user emotional states in another metaphoric form. Integrating the emotional space as part in the design is could motivate the design itself. Human mental states can be represented by multidimensional presentation reflected on our five sense, color integration with facial images, sound integration with the generated readout text, all in real-time animated with the transition state of the human user.

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An Analytic Method of Seasonal Reference in Japanese Haiku-Poem†

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Abstract— *This paper makes an overall design by means of an analytic method to determine the season word of a given "haiku": In Japan, there has been a unique poem style known as the "haiku", which (1) takes three parts of 5, 7 and 5 syllables, (2) contains a fragment of 5 syllables followed by a phrase of 7 and 5 syllables, a phrase of 5 and 7 syllables followed by a fragment of 5 syllables, or unifies three parts without any fragment and phrase separation, and (3) involves a season word for a seasonal reference. The season word must be a key word in the haiku. However, there is a critical problem to identify the season word of a haiku, when it has got more than one season word. It has been traditionally determined by the intention of the writer with reference to the sense and sensibility. We organize a methodology to see seasonal reference with lexical and logical analyses of the given haiku in a text form. Not all haikus are logically analyzed, but some can be so that they are experimentally consistent with the sense.*

Keywords— *Application of logic to Japanese poem, Applied logic (ISY)*

1. INTRODUCTION

FOLLOWING the book ([1]), we see that there is a unique poem style renowned as a "haiku" in the Japanese language. The haiku takes the form:

(i) to take three parts of 5, 7 and 5 syllables, where one syllable consists of a consonant followed by a vowel, except the consonant n.
(ii) to contain a fragment (consisting of one part) and a phrase (consisting of two parts) or to unify 5, 7 and 5 syllables without any fragment and phrase separation.
(iii) to involve a season word for a seasonal reference.

In English, the poetry is enjoyed even at a primitive stage such that there is a starting set of rules:

(i) to write in three lines that are short, long, short without counting syllables.
(ii) to make sure that haiku has fragment and phrase.
(iii) to have some element of nature.
(iv) to use the verb in the present tense.
(v) to avoid capital letters or punctuation.
(vi) to avoid rhymes.

With the usage of capital letters or punctuation, there is another way to follow the 5, 7 and 5 syllables ([2]). For the illustration of haiku all in this paper, we refer to English translations of haikus, which Basho made, from the book ([2]). For example,

In this hush profound,
Into the very rock it seeps —
The cicada sound.

(A) Technical Interest of Haiku

With reference to the above rules (iii) and (iv), the season word in the Japanese haiku is free from the constraint at that stage of the book ([1]). However, we think of the season word as essential in the haiku written in Japanese, because Japanese likes the situation which is:

(a) to denote some instance or pause in an environment where the poem writer has been or is.
(b) to denote a time point in the period when natural phenomena were, are and would be changing.

In general, except the haiku where there is no season word, we are allowed to have the cases that:

(i) there is just one season word.
(ii) there are more than one season word.

We have example:

How many cloud shapes
Capped the peak before the moon
Rose on Moon Mountain?
(cloud shape: summer, moon: autumn)

(B) Problem of Haiku Season Word

If there is only one season word, then we can enjoy the haiku by it as a key word. To automate the process of detecting the season word or none for both of the above cases, we face a problem of how we could find it for a given haiku. From the view of arts, what word is seasonal in a haiku is concerned with sensibility of the writer and the readers, inspired by it. There is some Japanese explanation

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that the season word is determined by the writer's mind itself, but no theory to determine it from the context of the haiku. It may be relevant to haiku's content. That is the problem from the analytic view by which we can partly see semantics of the haiku, and with which we can enjoy the haiku more familiarly.

Hence we are interested in the analysis problem of the season word contained in a Japanese haiku. If there are more than one season word, the problem is mainly related to the preference of one word.

(C) Analytic Solution

With the implementable lexical analysis of the haiku text, we aim at a logical analysis to classify and identify the season word or none with negations (denoting negative information processing). This logical analysis is motivated by a structural way to prefer one word in a category among more than one candidate word.

The logical analysis presents a method to organize an automated system to find out the season word. Experiments can be made, if both lexical and logical analyses are combined well.

This problem and a system construction as some solution of it would be an interdisciplinary aspect between artistic preference in arts and logical analysis in computing.

(D) Paper Organization

The paper is organized as follows. Section 2 is concerned with category of season words and with a logical method to represent it. In Section 3, a logical analysis is presented for the preference of season word. In Section 4, the system design is shown in relation to the logical analysis of Section 3. A formal aspect of the interpreter is described for preference of season word in the haiku-processing. In Section 5, we have an outlook at the system implementation. In Section 6, concluding remarks and considerations are made.

2. Season WORD IN HAIKU

2.1 Category of Season Words

In this section, we present some attributes of the season word. It contains:

(i) a reference to a seasonal aspect.
(ii) a suggestion of a spatial aspect.
(iii) a relevance to an emblem of sense.

We have the corresponding examples:

(i) What a cool, summer breeze!
Here, I make myself at home,
Rest, and take my ease.

(ii) O'er wild ocean spray,
All the way to Sado Isle
Spreads the Milky Way!

(iii) The river Mogami
Has drowned the hot, summer sun
And sunk it in the sea!

If we take a logical analysis for detection of the season word, the third item cannot be captured, but the first two aspects may be understood. The attributes may be partially categorized. The season word is evidently classified as referring to one of seasons: spring, summer, autumn and winter. It is also regarded as referring to the one in 7 categories: weather, astronomical aspect, geography, event, life, animal, and plant.

The season word categorized in weather, astronomical aspect, geography, event or life can preferably refer to the seasonal decision, even if there are more than one season word.

2.2 Logical Method

When we have more than one season word in a haiku, we must prefer some one as a primary season word which definitely determines the situation of the haiku. Based on the category, the primary season word may be inferred such that the preference of a season word to other words may be logically represented.

The predicate to denote preference of m to n for the primary word is defined to be

$$pref(m,n)=\begin{cases} true & \text{if } m \text{ is a primary season word and} \\ & n \text{ is not a primary season word,} \\ & \text{or } m \text{ is a season word and} \\ & n \text{ is not a season word,} \\ false & \text{otherwise,} \end{cases}$$

where variables *m* and *n* stand for words, or none (which is a special "symbol" and not even a season word). Note the case that we may see the season of the given haiku by means of some interactive method between a designed system and a system user. By such an interaction, the season of the haiku may be supposedly identified for the purpose of knowing which is the primary season word. For simplicity, this paper does not deal with such an interactive way.

Regarding whether it is a primary season word, we make use of the predicate *primary(x)* for the word, which may contain negations in 2-valued or 3-valued logic.

The 3-valued logic contains three truth-values **t**, **u** and **f**, where the value **u** stands for the undefined. Three negations, *not* (default negation), $\sim_w$ (weak negation) and $\sim_s$ (strict negation) as in [3] may be relevant to the representation of the predicate *primary(x)*.

	not	$\sim_w$	$\sim_s$
t	**f**	**f**	**f**
u	**u**	**t**	**f**
f	**t**	**t**	**t**

Table 1. Negations.

Let *season_w(m)* be a predicate to state that the word *m* is a season word. Also let *categorized(m)* be a predicate to state that the word *m* may be categorized as a supposedly primary word for a haiku, with reference to category of season words. The predicate *categorized(m)* is sensitive to an association with the primary (season) word. It is not always logical, but often rather related to some sense of the writer or the reader. However, by means of the predicate, we represent preference or non-preference of a season word with reference to the role of the primary word.

We have preference in terms of strict and default negations among the above three. The negation *not* is used to state that it is not a primary season word. Unless a season word is categorized, it is regarded as negated for the role of the primary word. If a word is not a season word, it is strictly negated for a primary season word. The strict negation $\sim_s$ is used to state that it is not a season word, nor a primary word.

In the case that negations $\sim_s$ and *not* are adopted:

- If both *season_w(m)* and *categorized(m)* then *primary(m)*.
- If *not season_w(m)* then $\sim_w$ *primary(m)*.
- If *season_w(m)* and *not categorized(m)* then *not primary(m)*.

3. LOGICAL ANALYSIS TO IDENTIFY SEASONAL REFERENCE

We must prepare for the predicates:

(i) *Season(x,m)* stands for the case that the word m is the primary season one among the list of words *x*. If *x* is empty, "*none*" is assigned to *m*.
(ii) *pref(m,n)* is as in Section 2, to stand for a preference of *m* (as the primary word) to *n*.
(iii) The predicate *primary(m)* states that the word *m* is regarded as a primary season one.
(iv) The predicate *season_w(m)* states that the word *m* is a season one.
(v) The predicate *categorized(m)* states that the word may be acknowledged as a supposedly primary one, with reference to category of season words.

By means of the view of logical analysis to identify the primary word, we have logical relations among predicates, some of which are now re-stated by the same manner as in the previous section. *first(x)* is the first element of the list *x*, while rest(x) is the list obtained by removing *first(x)* from *x*.

(a) If the list *x* is empty then *Season(x,none)*.
(b) If *Season(rest(x),a)* and *pref(first(x),a)* then *Season(x,first(x))*.
(c) If *Season(rest(x),a)* and *pref(a,first(x))* then *Season(x,a)*.
(d) If *Season(rest(x),none)* and $\sim_s$ *primary(first(x))* then *Season(x,none)*.
If *primary(a)* and *not primary(b)*, or *season_w(a)* and $\sim_s$ *primary(b)*, or *season_w(a)* and *b* is *none*, then *pref(a,b)*.
(e) If *season_w(a)* and *categorized(a)* then *primary(a)*.
(f) If *not season_w(a)* then $\sim_s$ *primary(a)*.
If *season_w(a)* and *not categorized(a)* then *not primary(a)*.

Now take the haiku:

How cool the autumn air!
I'll peel them and enjoy them --
The melon and the pear.

(i) It is clear that *season_w(autumn air being cool)*.
From the categorical classification,
categorized(autumn air being cool)
so that *primary(autumn air being cool)*.
(ii) We also see that
season_w(melon) and *season_w(pear)*.
But we have the negated predicates
not categorized(melon) and
not categorized(pear).

The logical analysis is automated by means of an interpreter whose formal aspect is presented in what follows, so that the negated predicates
not primary(m) and $\sim_s$ *primary(m)*
may be available.

4. RULE-BASED DATABASE WITH PREFERENCE

4.1. Negation versus Preference

The logical analysis to identify the primary word can be implemented by the representation of rule-based database and its retrieval. The rule-based database may be expressed by logic programs with negations, where the negations are built in an expression of preference. Regarding the present method of preference, the backgrounds of logic programming with negation is given by [4], [5], [6], [7], [8].

The rule-based database consists of (a)-(f) statements as in Section 3. The relation can be stated by the (clausal) form:

$$A \leftarrow B_1,\ldots,B_l, not\,C_1,\ldots,not\,C_m, \sim_s D_1,\ldots,\sim_s D_n,$$

where:

(i) $A, B_i\ (1 \le i \le l)$, $C_j\ (1 \le j \le m)$, and $D_k\ (1 \le k \le n)$ are predicates.
(ii) The negations *not* and $\sim_s$ denote default and strict ones, respectively.

The form means that:

If B_1 and … and B_l and *not* C_1 and … and *not* C_m and $\sim_s D_1$ and … and $\sim_s D_n$ then *A*.

In accordance with the statements (a)-(f) in Section 3, we demonstrate the relations in the clausal form:

(a) $Season(nil, none) \leftarrow$
(b) $Season(x,\ first(x)) \leftarrow Season(rest(x), a),\ pref(\ first(x), a)$
(c) $Season(x, a) \leftarrow Season(rest(x), a),\ pref(a,\ first(x))$
(d) $pref(a,b) \leftarrow primary(a), not\ primary(b)$
$pref(a,b) \leftarrow season\_w(a), \sim_s\ primary(b)$

$pref(a, none) \leftarrow$

(e) $primary(a) \leftarrow season\_w(a), categorized(a)$

(f) $not\ primary(a) \leftarrow season\_w(a), not\ categorized(a)$

$\sim_s primary(a) \leftarrow not\ season\_w(a)$

Note that the rule-based database is represented by a set of clauses (clausal forms) as above, where the negations *not primary(a)* and $\sim_s$ *primary(a)* of the item (f) occur only in the right-hand sides (bodies) of other clausal forms, for a simpler procedure construction.

A query to ask whether
B_1 and … and B_l and *not* C_1 and … and *not* C_m
and $\sim_s D_1$ and … and $\sim_s D_n$
holds for the database is represented by the goal statement (which is the negation of a query) of the form:

$$\leftarrow B_1, \ldots, B_l, not\ C_1, \ldots, not\ C_m, \sim_s D_1, \ldots, \sim_s D_n.$$

It means that:
The conjunction of B_1 and … and B_l
and *not* C_1 and … and *not* C_m
and $\sim_s D_1$ and … and $\sim_s D_n$ is contradictory.

For example, a query of whether the predicate *Season(x,m)* holds, that is, the word is a primary word of the list *x* is represented by its negated form $\leftarrow Season(x,m)$ to obtain a substitution (calculation) of a value (term) for the variable m. For the given rule-based database and the goal statement, we have in [3] a procedure to see whether the query denoted by the goal statement is well answered with reference to the database.

4.2. Description of Procedure

As in [3], we recursively define the relations $suc_P, fail_P \subseteq Goal$ for the set *Goal* of goals, where *P* denotes the rule-based database of the ground version, that is, the rule-based database containing no variable: By the relations $suc_P(\leftarrow A)$ and $fail_P(\leftarrow A)$, we have the meanings that the goal (statement) $\leftarrow A$ succeeds, and that the goal $\leftarrow B$ fails, respectively. The relations are to be the least set satisfying the following rule closure, where two rules (a) and (b) are contained for the rule closure to be compositional. A (possibly empty) sequence of literals (predicates or their negations) is denoted by using letters like *G*, G_1, G_2 ,…, where a sequence of literal sequences is also regarded as a sequence of literals.

(a) $suc_P(\leftarrow G_1), suc_P(\leftarrow G_2) \Rightarrow suc_P(\leftarrow G_1, G_2).$

(b) $fail_P(\leftarrow G) \Rightarrow fail_P(\leftarrow G_1, G, G_2).$

(i) $suc_P(\square).$

(ii) $suc_P(\leftarrow G), (A \leftarrow G) \in P \Rightarrow suc_P(\leftarrow A).$

(iii) $fail_P(\leftarrow A) \Rightarrow suc_P(\leftarrow not\ A).$

(iv) $fail_P(\leftarrow A) \Rightarrow suc_P(\leftarrow \sim_s A).$

(v) no clause (in P) with A in head $\Rightarrow fail_P(\leftarrow A).$

(vi) for all clauses $A \leftarrow G$, $fail_P(\leftarrow G) \Rightarrow fail_P(\leftarrow A).$

(vii) $suc_P(\leftarrow A) \Rightarrow fail_P(\leftarrow not\ A).$

(viii) no relation $fail_P(\leftarrow A) \Rightarrow fail_P(\sim_s A).$

The procedure is in accordance with the set (which is not always the least) satisfying the above rule closure. The procedure is described for the database of the ground version. If the database involves variables, the procedure may be graded up to the first-order version, with negations containing no variable for the safe-rule (as surveyed in [9]).

In the sense that the following theorem holds, the procedure is consistent. The consistency is relevant to consistent reasonings as in [3], [10], [11], [12], [13], [14], [15], [16]. The proofs of Theorems 4.1 and 4.2 are verbally accounted in Appendix.

Theorem 4.1: Assume a predicate *A* for a rule-based database *P*. When there is a succeeding derivation from the goal $\leftarrow A$ for P, there is no failing derivation from the goal $\leftarrow A$.

We observe a model theoretic aspect of the succeeding and failing derivations.

Theorem 4.2: Assume a rule-based database *P* of the ground version with strict and default negations. Take the sets:

(i) $T = \{A \mid A \text{ is a predicate such that} \leftarrow A \text{ succeeds}\}.$

(ii) $F = \{B \mid B \text{ is a predicate such that} \leftarrow B \text{ fails}\}$.

The pair *(T,F)* is a 3-valued Herbrand model of *P*.

5. SYSTEM DESIGN TO SEE PRIMARY SEASON WORD

The automated system, which is implemented to infer a primary season word for a given haiku, contains the system modules of:

(i) lexical analysis of haiku texts and transformation of real haiku texts to lists of words.

(ii) rule-based database, which includes relations among season and primary words with the list *x*.

(iii) logical analysis interpreter to find a primary season word for a list of words, with reference to the rule-based database.

The methods of modules can be demonstrated by Table 2.

Modules	Methods
(i) Lexical analysis and Transformation to word	(i) Syntactic analysis
(ii) Rule-based database	(ii) Logic programming with negation
(iii) Interpreter	(iii) Succeeding and failing derivation

Table 2. Methods of System Modules.

5.1. Lexical Analysis

The Japanese haiku contains a sequence of 17, or less or more syllables without any separation pause or symbol between syllables. We must find a pause between words by lexical analysis so that the haiku can be a sequence of words.

Based on a sequence of words, we make a processing to get a list of words which may be season words, by excluding words or a sub-sequence of words which cannot be season words. Words included in the parts like pronoun, adverb and so on can be excluded in any category of season words. The system JUMAN, whose improved version appears in [17], is available for this system design.

- The exclusion rules are as follows.
- The word, which is a pronoun, an adverb, an adnominal, an auxiliary verb, a conjunction or an interjection, can be excluded.
- The word which is a conjunction, followed by another word, can be neglected such that the following one is examined.
- The word, which is just a suffix, can be neglected.
- The sequence consisting of a noun, “no” (in Japanese) and a noun is regarded as a word.
- Some sequence of a noun and a verb is regarded as a word.

5.2. Rule-Based Database

As demonstrated in Section 4, we may implement the system to infer the primary season word for a given haiku.

After the stages in lexical analysis and transformation of it to a list of words, the system executes the following routine, based on the rule-based database and implementation module (constructed by means of the formal method as in Section 4). Let *x* be the list of words, while the variable *m* contains a season word or *none*.

```
procedure  primary_word_detection;
begin
m := none;
while (x ≠ nil) do
   begin
     if the goal ← Season(x, first(x)) succeeds
     then begin m := first(x); x := nil end
     else x := rest(x)
   end;
return(m)
end.
```

5.3. Illustration

We now consider the primary season words of the previous examples.

For the haiku:

How many cloud shapes
Capped the peak before the moon
Rose on Moon Mountain?

It is easy for the designed system to detect both *season_w(cloud shapes)* and *season_w(moon)*. We can have both

categorized(cloud shapes) and
categorized(moon)

so that the system must fail, unless the word “moon” included in

“the moon” and “Moon Mountain”

are identified. If they are identified, then the word “moon” must suggest the mountain name so that we have *not primary(moon)*. In this case, *primary(cloud shapes)*.

6. CONCLUDING REMARKS

In this paper, we make use of strict and default negations for preference of the primary season word of the haiku which may involve more than one season word. The primary word must be both a season word and a categorized one. The acknowledgement of a category contains sensibility, but can be made by a classification of season words. Unless the word is seasonal, it may be regarded as strictly negated. Even if it is seasonal but not categorized, it is interpreted as default negation.

The database for the preference of primary words is incorporated in succeeding and failing derivations. The SLDNF resolution may be available.

(1) The well-founded model ([18], [19]) is acquired for the modified database (logic program) obtained by substituting default negation for strict one.

(2) The well-founded model may be even a model of the original database with strict and default negations. (The proof is omitted.)

However, the succeeding and failing derivations work well for the database with strict and default negations, they are more refined than the SLDNF resolution derivations such that the derivations are consistent and contain model theoretic aspect in the sense of Theorem 4.2. On the other hand, more specific and concrete treatments are not yet made, while the preference theory and practice have begun as in case of a conflict between defaults of [20].

From broader views, this paper’s treatment is expected to be included in diagnosis as in [21] or in specification as in [22] for haiku analysis by means of semantic aspect. Interactive haiku analysis and synthesis systems are the subject of haiku-processing by applying agents (as functions) in [23]. Whether relation between logical analysis (in [24]) and Japanese sensibility is made clear is still a problem.

Appendix

(A) Proofs

(1) Proof of Theorem 4.1:

Assume that there is both a succeeding derivation from the goal $\leftarrow A$ and a failing one from the goal $\leftarrow A$. Because there is a succeeding derivation, by means of the rule (ii) with the clause $A \leftarrow G$ in *P*, we have a goal $\leftarrow G$. At the same time, a goal $\leftarrow G$ is obtained by means of the rule (vi), since there is a failing derivation from the goal $\leftarrow A$. By the same reasons for both succeeding and failing derivations, we reach a case without loss of generality that the goal $\leftarrow G$ succeeds and the goal $\leftarrow G$ fails, where *G* takes the form

$\leftarrow not\ B_1, \ldots, not\ B_m, \sim_s C_1, \ldots, \sim_s C_n.$

Because of the succeeding derivation from goal $\leftarrow G$ with reference to the rule (iii) or the rule (iv),

any goal among $\leftarrow B_1, \ldots, \leftarrow B_m$ fails and

any goal among $\leftarrow C_1, \ldots, \leftarrow C_n$ fails.

Because of the failing derivation from the goal $\leftarrow G$ with reference to the rule (vii) or the rule (viii),

some goal among $\leftarrow B_1, \ldots,$ and $\leftarrow B_m$ succeeds, or no goal among $\leftarrow C_1, \ldots,$ and $\leftarrow C_n$ fails.

It follows that there is some predicate B_j such that:

- the goal $\leftarrow B_j$ fails.
- the goal $\leftarrow B_j$ succeeds.

For the above reason, we recursively reach the assumption more than once that the goal $\leftarrow A'$ succeeds and the goal $\leftarrow A'$ fails. This is a contradiction, because the goal $\leftarrow A'$ cannot succeed, owing to the illegal recursion. Hence the first assumption is contradictory such that this concludes the proof. q.e.d.

(2) Proof of Theorem 4.2:

Note that the program contains no variable. By Theorem 4.1, the pair (T, F) is consistent, that is, a 3-valued Herbrand interpretation. For any clause

$A \leftarrow B_1, \ldots, B_l, not\ C_1, \ldots, not\ C_m, \sim_s D_1, \ldots, \sim_s D_n,$

we have the following cases:

(i)

$\forall B_i.[(1 \le i \le l) \Rightarrow B_i \in T]$ and
$\forall C_j.[(1 \le j \le m) \Rightarrow C_j \in F]$ and
$\forall D_k.[(1 \le k \le n) \Rightarrow D_k \in F]$
$\Rightarrow$
$\forall B_i.[(1 \le i \le l) \Rightarrow \leftarrow B_i$ succeeds] and
$\forall C_j.[(1 \le j \le m) \Rightarrow \leftarrow C_j$ fails] and
$\forall D_k.[(1 \le k \le n) \Rightarrow \leftarrow D_k$ fails]
$\Rightarrow \leftarrow A$ succeeds
$\Rightarrow A \in T$, that is, the clause is true.

(ii)

$\exists B_i.[(1 \le i \le l)$ and $B_i \in F]$ and
$\exists C_j.[(1 \le j \le m)$ and $C_j \in T]$ and
$\exists D_k.[(1 \le k \le n)$ and $D_k \notin F]$
$\Rightarrow$ the clause is true.

(iii)

$\forall B_i.[(1 \le i \le l) \Rightarrow B_i \notin F]$ and
$\exists B_i.[(1 \le i \le l)$ and $B_i \notin T]$ and
$\forall C_j.[(1 \le j \le m) \Rightarrow C_j \notin T]$ and
$\exists C_j.[(1 \le j \le m)$ and $C_j \notin F]$ and
$\forall D_k.[(1 \le k \le n) \Rightarrow D_k \in F]$
$\Rightarrow$
$\forall B_i.[(1 \le i \le l) \Rightarrow \leftarrow B_i$ does not fail] and
$\exists B_i.[(1 \le i \le l)$ and $\leftarrow B_i$ does not succeed] and
$\forall C_j.[(1 \le j \le m) \Rightarrow \leftarrow C_j$ does not succeed] and
$\exists C_j.[(1 \le j \le m)$ and $\leftarrow C_j$ does not fail] and
$\forall D_k.[(1 \le k \le n) \Rightarrow \leftarrow D_k$ fails]
$\Rightarrow \leftarrow A$ does not fail
$\Rightarrow A \notin F$, that is, the clause is true.

Hence any clause of the program *P* is true in the pair (T, F). That is, the pair is a model. This completes the proof. q.e.d.

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Topological Consideration about the Center in Drawings by Children

Motoya, Yoshiko

Abstract— *The concept "center" plays one of the most important roles in the thinking and behavior by children. In their drawings, children find difficulties in representing a center or a centralization-expansion. In the cognition of space by children, the structure and logic of center relates to the more complicated problems of core and circuit, axis and rotation, pairs and alternation and so on. We have analyzed and examined the drawings of a model, and tried to compare it with their physical movement (dance).*

Keywords— geometry topology domain drawing *center core axis rotation*

Introduction

Children from 3 to 5 year old are told to draw a model (fig. 1). The model is devised for children to think about the inside and outside, pairs, connections, direction of figures, exceptional cases, and through these to find the various meanings of the concept of center. Children 4 year old, played a dance (Japanese YOSAKOI dance) after the first drawing, and then drew it again. We examined what kind of improvement they showed in the drawing after the movement, and to what extent was the effect in their cognition certified. To draw the center correctly, children must understand the opposites, such as center and circumference, pairs and alternation, axis and rotation and so on. Children will be expected to make progress in the understanding of center by way of the physical praxis and the intercourse between others.

The cognition of center

[Grph.1] shows how and to what extent children can draw the center as a point. 5 year old children understand the meaning of center and can draw it clearly, though many 4 year old children find difficulties.

When children draw a picture without any suggestions, they draw it in many different ways, for example with one color, with two or more colors separately, by the opened contour lines and so on. [Grph 2] shows the relation between two colors from the standpoint of the connection of the inside and the outside. In the drawings by 4 year old children, compared with that of 5 year old children, two colors do not successfully conform to each other. When two figures are drawn in different directions, they cannot centralize to one central point, even if the two domains (the inside and the outside) come in contact with each other. In order that lines may centralize to one point, the axes of figures must be directed to it.

Figure 1: Model

2005.5.11	N	pretest sheets	posttest sheets	total sheets
3 year old children	5	5		5
4 year old children	21	32	31	63
5 year old children	25	41		41
total	51	78	31	109

(N is number of children)

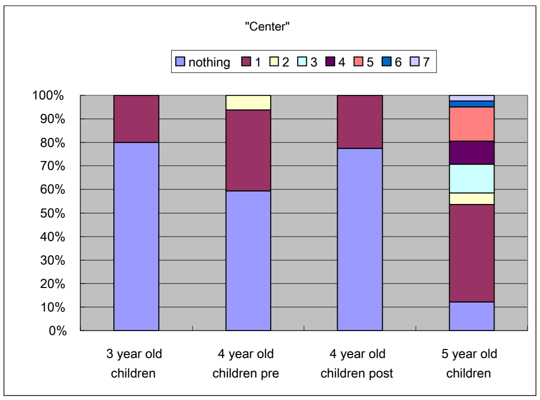
Table 1: Number of children and sheets

Though inside circle and outside circle in the model are both closed, children drew them by various opened and closed lines. [Grph.3] shows the case in the inside domain, and [Grph.4] in the outside domain. They could draw the closed line in the outside domain earlier than that of the inside domain.

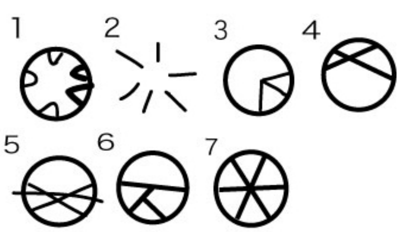
[Grph.5] shows the relation of connection of areas between the and the outside domain toward the center, from the standpoint whether they are directed toward the center. To fix the center, it is necessary for children that they can draw both the relation of connection and the direction of areas toward the center. Pictures are divided into several groups, 1: some without inner area, 2: some inner areas and outer areas are separated, 3: some inner and outer areas do not correspond, 4: in some both areas are corresponded but are incomplete, and 5: both areas correspond exactly. Though 3 year old children belong from 1, 2, 4, children 5 year old belong to 1~5. 4 year old children are in a transition period.

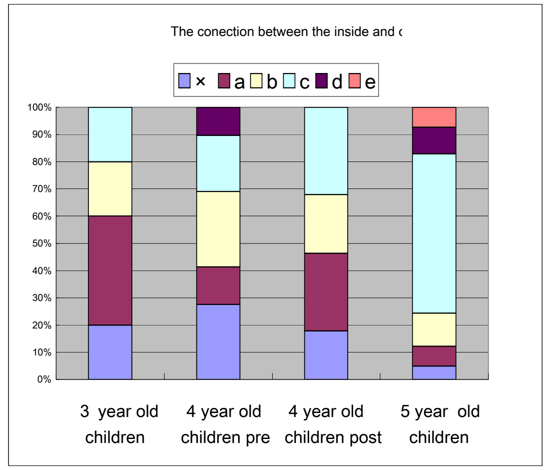
[Grph.6] shows if children take notice of the heterogeneous pair, ie. inner white area and outer green area, in the model. Other pairs are pink pairs, a blue pair, a yellow pair. It is important to watch whether children draw pairs without noticing the distinction between the inside and the outside areas, or noticing it.

To settle the center, they must be able to draw the relation of inside and outside, opened and closed, connection of areas, direction towards the center, combination of pairs. These are the elements for children to construct the concept of center.



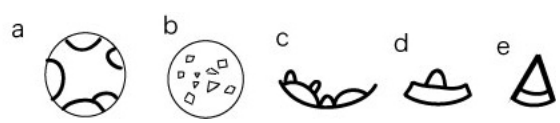
	nothing	1	2	3	4	5	6	7	total
3 year old children	4	1							5
4 year old children pre	19	11	2						32
4 year old children post	24	7							31
5 year old children	5	17	2	5	4	6	1	1	41





	3 year old children	4 year old children pre	4 year old children post	5 year old children
×	1	8	5	2
a	2	4	8	3
b	1	8	6	5
c	1	6	9	24
d	0	3	0	4
e	0	0	0	3

Graph 1: Change in the cognition of center in accordance with age



Graph 2: Connection of the inside and the outside

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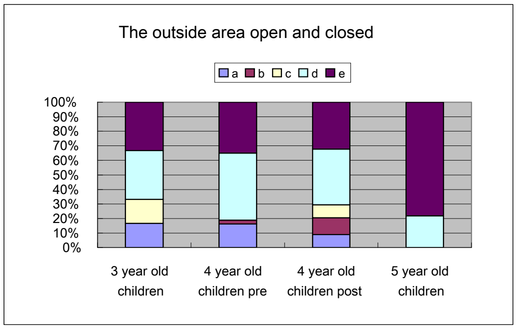
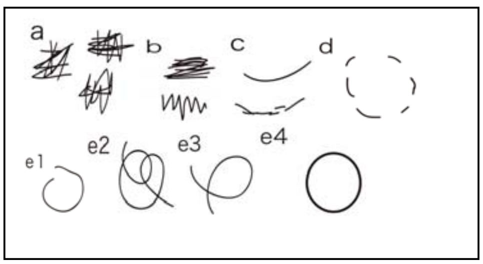
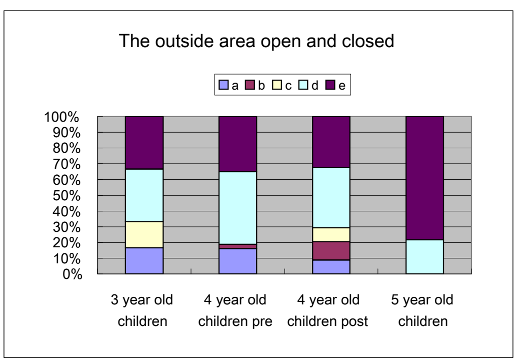


	a	b	c	d	e
3 year old children	2	1	0	0	0
4 year old children pre	13	6	2	8	1
4 year old children post	6	9	0	5	8
5 year old children	1	0	1	24	16

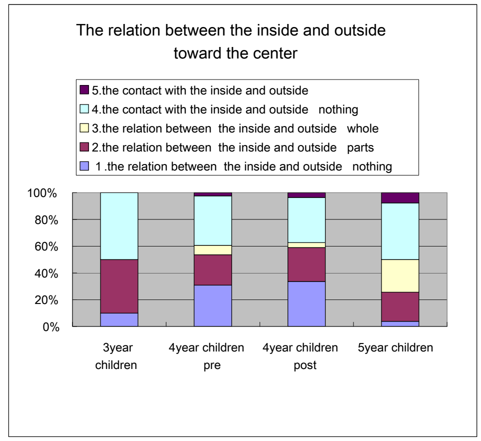


Graph 3: Opened and closed in the inside domain

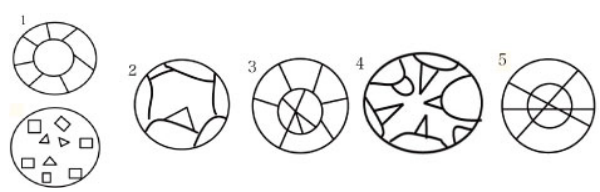


	a	b	c	d	e
3 year old children	1	0	1	2	2
4 year old children pre	6	1	0	17	13
4 year old children post	3	4	3	13	11
5 year old children	0	0	0	10	36

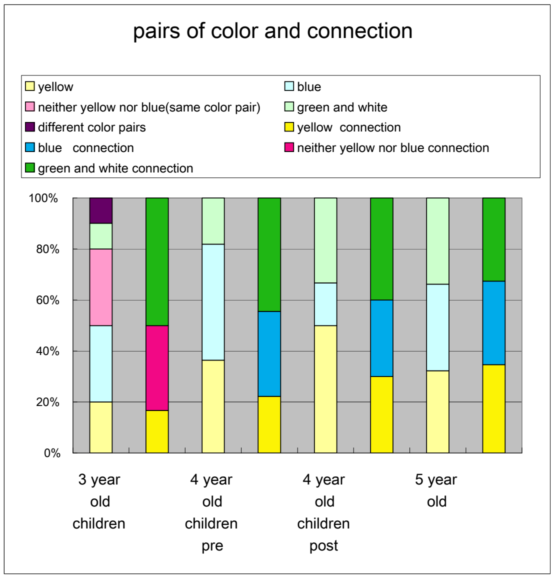
Graph4: Opened and closed in the outside domain



	3year children	4year children pre	4year children post	5year children
1 .the relation between the inside and outside nothing	1	26	28	3
2.the relation between the inside and outside parts	4	19	21	17
3.the relation between the inside and outside whole	0	6	3	19
4.the contact with the inside and outside nothing	5	31	28	33
5.the contact with the inside and outside	0	2	3	6



Graph5: The relation of connection between the inside and the outside domain toward the center



	yellow	blue	neither yellow nor blue(same color pair)	green and white	different color pairs	yellow connection	blue connection	neither yellow nor blue connection	green and white connection
3 year old children	2	3	3	1	1	1	0	2	3
4 year old children pre	4	5	0	2	0	2	3	0	4
4 year old children post	3	1	0	2	0	3	3	0	4
5 year old	19	20	0	20	0	18	17	0	17

Graph6: Pairs of colors

Learning a center - Analysis of the pictures by 4 year old children

What do 4 year old children in the drawing of the model think and have trouble with in the course of their understanding of the center. We think 4 year old children stand at a turning point, because they are yet insufficient to understand the relation of elements or areas, they are yet undisciplined and have poor diversity, though they have great possibilities in development.

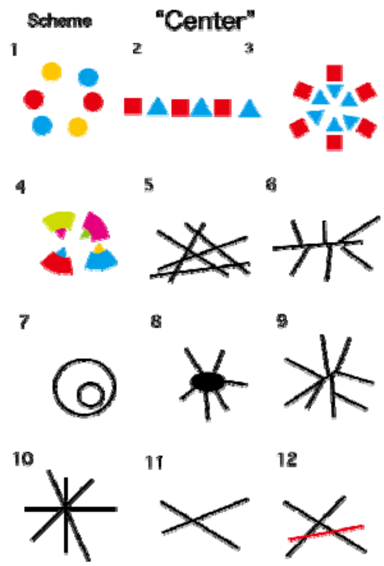


Figure 2: Scheme : 12 Patterns : pair , alternation, axis, rotation and so on

[Scheme] is a devised table, divided into 12 patterns which mean pair, alternation, axis, rotation, and various <centers>—spread center, wide center, point center, and so on—. We will take some examples from children's pictures to illustrate these patterns. In the pictures of children we find a common step in the development of the cognition of center, from the cognition of pairs, to that of alternation, that of the connection, and that of the direction to the center.

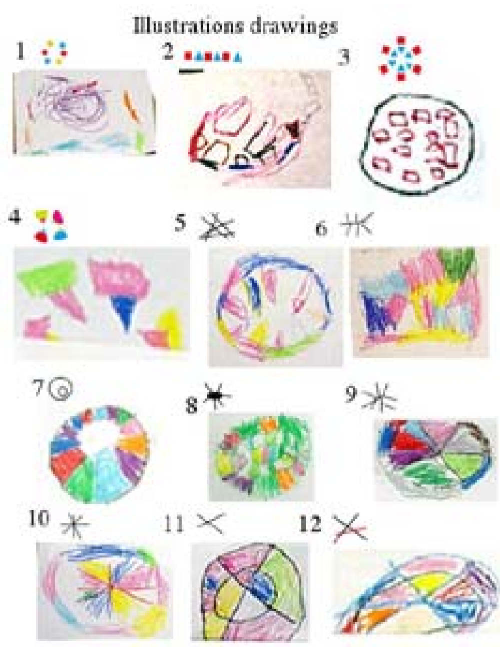


Figure 3: 12 illustrations : drawings by children

Cognition through the physical activity

We tried to elucidate the relation between the cognition of the center and physical activity. For this problem, children were told to play YOSAKOI dance after the first drawing. It is one of Japanese old folk dances, but we designed a new composition to this dance. Children were divided into two groups, red group and green group, and they danced looking at their tutors dance. We made no suggestion for the game, and we took notice of some movements in their behavior, to find what kind of movements they have learned from the tutor. We have analyzed these movement from the standpoint of centralization, and compared them with the drawings.

In the movements, there are noticeable elements, such as pairs and alternation, axis and rotation, center and circumference. Children learned in the movements noticing these elements, expressed them in their movement, and drew these <treasures> gained for themselves on the paper. In return, they made the best use of the understanding of the center in the drawing to their movements of the dance. Their cognition is one with their movement.

Figure 4 Photo Movement : YOSAKOI dance

We can see interesting relations between children's movements and drawings. Troubles in the movements are brought into the drawings. We find a noticeable coincidence between the troubles in the dance and those in the drawing (scheme).

1 Children make up pairs, but no reasonable movement to the center: scheme 1/2

2 At first turn to the right-hand, then to the left-hand : scheme 2

3 Movement of rotation in a pair around the other (children are told to move backward, feeling the other as an axis) : scheme 3

4 The pair connected with each other, but the center of rotation moves around the supposed axis : scheme 4

5 Center and circumference are diverse among pairs (surround, neighborhood) ; scheme 5

6 Pairs move along a line : scheme 6

7 Pairs move along a circle, but have no attention to the center: scheme 7

8 Each member of a pair can not move arround the center, though he is conscious of it : scheme 8/9

9 Each of a pair could not at first apprehend the center, but at the end of the play they could start approaching the center : scheme 10,11,12

The learning of center and cognition of space by children

In the movement a teacher helps children that they can for themselves seek the center, distinguish the central area from the middle area, end area, and circumference. It is important for children to apprehend the expansion of areas for a start, and then take notice of the center. Many children at first have trouble to find the center, and step by step comprehend its position and meaning. The teacher must analyze their process of overcoming the troubles, and from this result understand <the logic of children>.

Our research to the problem of the cognition of center by children is done from the standpoint of topological geometry, such as the connection between two areas, opened-closed of contour lines. The problem of center in the movement by children is decisively topological, not Euclidean. In this point, many teachers have no ideas or misunderstand the problem. In topology the character of parts does not consist of the character of the whole. Teachers, who had learnt only Euclidean geometry, are apt to see in the learning of center only the Euclidean character of center and circle, and fail to lead the proper development of understanding in the cognition of space. Children learn the significance of the center from the necessity of their own lives and activities, not from the system of geometry.

Only from the standpoint to draw the model correctly, it is of course right that the center is one point. But as shown in many drawings of 4 year old children, there were various <center> - line center, domain center, moving center -. These centers may represent their troubles. But are they only negative or incorrect centers? And by which means do children develop their <category> of the center? To what extent does the center play a role in their lives?

In the movement of a dance, it is important for children to move vividly so that they can comprehend the relation between the center and themselves, their direction to the center, and their part in the group or pair. Children who cannot see the relation between the center and circumference, the connection of areas, can not play a good partnership in pairs and have troubles in the dance.

The learning of the relation of the center and circumference is not significant only for the study of geometry but for the establishment of the self and for the relationship to others. By the topological and practical learning of the center, children can acquire appropriate action and thinking.

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