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## The Theory of Biomedical Knowledge Integration(IV)

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**Abstract** This paper presented some philosophic viewpoints of the Theory of BMKI(The Theory of Biomedical Knowledge Integration), a new exploration in BioMedical Informatics. It discussed an evolutionary relation from propositional calculus, predicate calculus, through framework, to neural network.. The differences in exclusivity and other natures were explored for physical systems(the real world), quasi-physical systems(the copies of the real world) and mental systems(the abstracts of the real world). Based on their behaviours in cognitive sciences and knowledge engineering, the new concepts quasi-infinity or –infinitesimal, potential knowledge, dynamic knowledge were introduced. This paper has also described so called “big-or” space which is the base of scientific understanding or association. Furthermore the paper put forward the viewpoint that “reasoning only can implement in an axiomatic space” and then outlined the building processes of such kind of space. At last so called “beacon-and-compass strategy” in BMKI was introduced.

**Key words** BioMedical Informatics, Biomedical Knowledge Integration, Artificial Intelligence of BioMedicine

The Theory of BioMedical Knowledge Integration(BMKI) is aimed at exploring the possibility, feasibility, philosophic principle, strategy, methodology, etc of the integration of large-scale and heterogeneous biomedical knowledge, including probing into the natures or attributes of the various relations, patterns, process, mechanisms, etc and their corresponding knowledge representing forms in biomedical knowledge fields. Here in this paper, the author discussed several most essential theoretical problems.

### 1. Rational Part and Non-rational Part of AI

H.L. Dreyfus and S.E. Dreyfus, in their article about the question AI is mind (or rational as called in this paper) models or brain (or non-rational) models in the book 《The Philosophy of Artificial Intelligence》 (Chinese translation) edited by Margaret A.B., described the differences between two kinds of model of AI. To clarify these descriptions I made a summarization of them and listed in Table 1.

Obviously the Theory of Bio-Medical Knowledge Integration(BMKI)<sup>[1-12]</sup> can't avoid such an

important subject, though it is not interested in the questions such as which kind of model is better at all. What BMKI most interested in are the questions like what essence makes the difference between two types of model; how the both models are related to each other; how they transform reciprocally, etc. For that purpose, the author briefly organized the several most important data or knowledge expression types based on an evolutionary viewpoint as shown in Fig. 1.

Those considerations let me get an association about other somewhat related problems: As a representative of rationalism, mathematics have met many crises in aspect of certainty (see the book by Morris Kline<sup>[13]</sup>, Chinese translation also) . As my identification, many of those crises, mentioned in that book and in the area of AI or knowledge engineering of Medical Informatics as well, are originated from the effects of infinity or infinitesimal. Although, in the mathematic history, the concept infinity or infinitesimal, which people can never experience, has induced the births of some new mathematics, eg differential calculus, Cantor's Set Theory, etc, the basic methods or principles, for instances " $1/\infty = 0$ " and  $S = \lim_{n \rightarrow \infty} a^n = 0$ , (if  $|a| < 1$ ), seem to be the pseudo-rational ones, not really rationalistic.

Thus my opinion is that the effects of quasi-infinity or -infinitesimal (defined in the following text) serves as a transformation or bridge between rational parts and non-rational parts of knowledge world, see Fig 2. That means BMKI will have to rely on both rational and non-rational or empirical operators, no matter we are willing to or not.

Since nobody can know what a infinity or infinitesimal actually is, it is perhaps difficult to give a definition to it. But we still might build a definition for so called quasi-infinity or -infinitesimal on the cognitive base.

**Definition 1** A quasi-infinity or -infinitesimal is a quantity or its reciprocal of a thing that is so large or small as to be beyond the cognitive ability at that time. The examples of quasi-infinity include the well-known exponent explosion of operation in AI, the relation between the dynamics of the numerous Brownian's particles in a container and its temperature and the transform from the contraction of the numberless myofilaments to the arm movement of a boxer, etc.

According to that if the relationships are activated or not, the knowledge types listed in Fig. 1 can be divided into two types:

**Definition 2** A potential knowledge is a knowledge unit which is composed of a set of elements and their relationships in existing or unactivated state. For examples, a rule base and its operating program, a semantic network, a framework, a neural network, etc in their storage state.

**Definition 3** A dynamic knowledge is a knowledge unit which is composed of a set of elements and their relationships in implementing or activated state. For examples, a program in running, a semantic network in operating, a neural network in working, a process, a movies or video, etc

## 2. The Difference between Mental Systems and Quasi-physical Systems

The first question for BMKI theory is, of course, what a knowledge world is. To the end, a knowledge world is a dialogue between human and nature, where human is the subject and nature, the object. Namely, it is the interaction between the mental systems and physical systems. The roles of mental systems are to simulate, map, fit or calculate the corresponding physical systems. That means any mental systems, even those high abstract systems, eg rational and irrational number systems in mathematics, have their physical systems in point. The relationship between the two kinds of the systems is roughly shown in Fig.3.

That is the movements and their laws of nature are mapping to human brain through sense organs, activating the movements and their laws of human brain, ie the functions of memory, conceptualization, thinking, etc. Parts of data or knowledge have been, to different extent, processed by the brain to create the corresponding mental systems of different levels, whereas others are simply mapped or copied from the original thing, to form its so called quasi-physical system.

**Definition 4** A quasi-physical knowledge is one which belongs to an individual or instances, eg the record of a patient, the video record of an event, etc.(see Fig. 4)

The reason why we should identify the new concept “quasi-physical knowledge” is because it attaches to its original physical object and its cognitive behaviours and features, such as openness, uncertainty, unexclusiveness, etc. follow the physical object as well. For example, the descriptions on the knowledge coverage of the Old Bao at the time five years latter are difficult, because it will continue to change following the reading course of that Mr.

Namely, the quasi-physical system is just like a “shadow” of its physical system, and the former inherits the cognitive features from the latter, including the openness, uncertainty, unexclusiveness, etc mentioned in the following text. Therefore as a whole, our knowledge world is a complex of the movements and the laws of the quasi-physical components of knowledge and the mental ones.

Two kinds of the components of knowledge world, however, are definitely different in their ways of movement or behavior and these differences have not been noticed enough by people in AI area. That overlook has made a lot of puzzlement in AI. An instance of them is reflected in the story presented by McCarthy: Priests and human-eaters(translated from the Chinese text).<sup>[14]</sup>

*Three priests and three human-eaters came to a river. There was only one boat on the river being able to carry two persons once. If the number of human-eaters was more than of priests at any side of the river, the priests would be eaten up by the human-eaters. The problem is how they could boat cross the river without the terrible situation happening.*

It is obviously that this difficult problem needs a design of strategy for boating of come-and-go, making them all cross over the river safely (see a solution in Fig. 5).

*Then you told this question to a guy. And after a deep thinking he suggested, “through the bridge at a half mile upstream”. “What is the bridge?” you asked, deeply astonishingly. Then you checked again the original text and can do nothing but confess that the declaration “there is no bridge on the river upstream and downstream” was never mentioned. Then you corrected the problem, to exclude any bridges across the river and put forward it again. The fool suggested to get over the river by helicopter. And after you couldn’t but exclude any helicopter, he suggested by a fly horse or hanging other people outside the boat when two persons were rowing.*

*Now you realized that he was not only a fool, but also a creative one. You were completely disappointed in making him understand exactly the nature of the difficult problem and at last told*

*him the solution. It even made you angrier that he asked in retort by the reasons that the boat may leak or without oars. When you had remedied those omitted things, he presented the possibility of existing a river monster and swallowing down the boat...*

Let's look at the basic differences between "you" and "the fool": As a scholar of AI, "you" considered the story as mental system, whereas "the fool" thought it was a physical or quasi-physical one. Just as its name implies, the typical mental systems, such as an arithmetic of pattern recognition or a computer program, are the products by the movement of abstracting and conceptualization by the human brain. A very important point is that **mental systems may be certain and exclusive, ie any things wouldn't exist except those mentioned and implied in the systems**. But **physical systems or their quasi-physical ones are never exclusive. They are, in nature, infinite, non-prognosticated, uncertain, boundless, diverging,...** When we say in Euclidean geometry that "if the two corresponding sides and the angle determined by them are equal, then the two triangles are congruous", we can't ask the stupid questions such as "if there is a fly fallen on one of the triangles, then how we can say about it". Because it is exclusive in Euclidean geometry, though it is quite possible for physical systems or their quasi-physical systems. Thus another important conclusion by BMKI is that, **theoretically speaking, a reasoning can be realized only in mental systems and can't be done in any physical systems.**

Table 1 The differences between the models of symbol-logic type and neural network type.

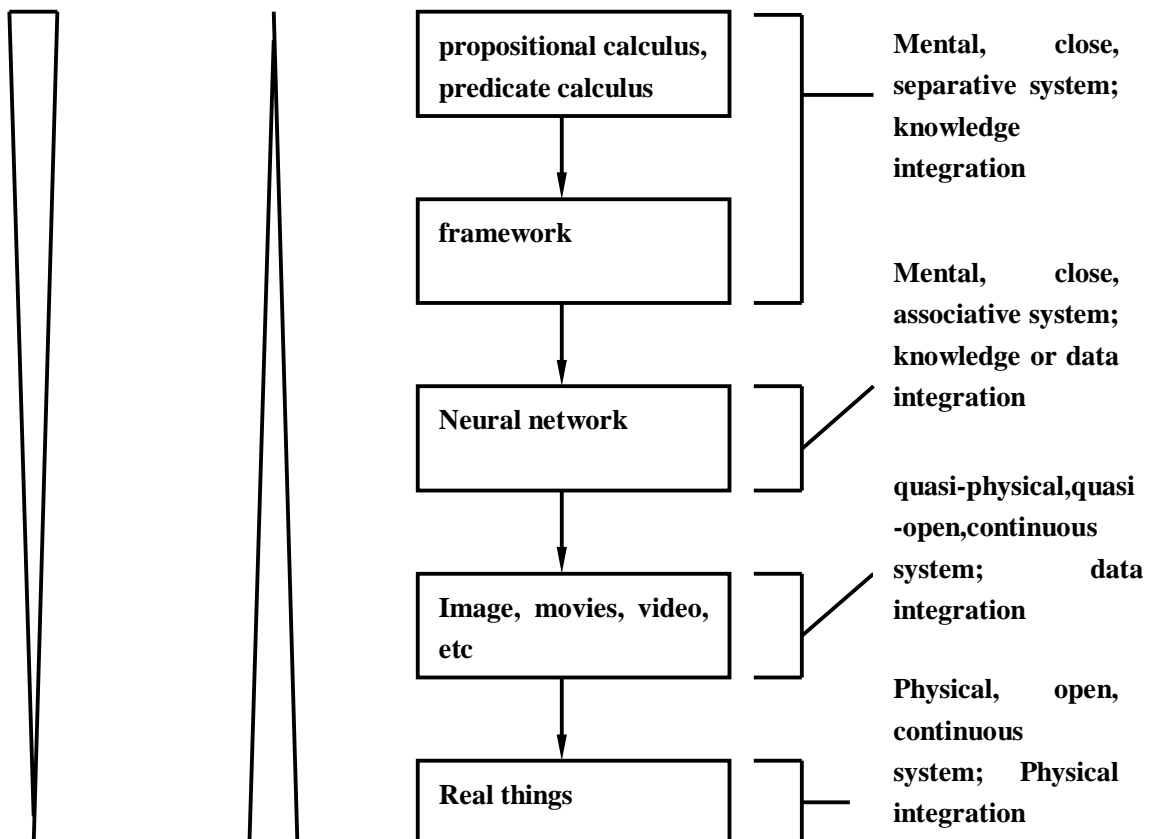
|                                  | symbol-logic type   | neural network type   |
|----------------------------------|---|---|
| <b>representative scientists</b> | Newell A, Simon H,<br>Minsky M,<br>Papert S, Husserl E etc                                | Wittgenstein L, Rosenblatt F,<br>Heidegger M, etc                     |
| <b>Nature</b>                    | mind model  | brain model   |
| <b>Philosophical background</b>  | atomism   | phenomenology   |
| <b>view point bifurcation</b>    | binary strings can represent<br>every things, element unrelated<br>with context           | common world can't be described by<br>elements unrelated with context |
| <b>methodology</b>               | to find original elements and<br>logic relations  | whole and associative methods   |
| <b>Characteristic Questions</b>  | To let a system have the character<br>X, which logic structure the<br>System should have? | Which kind system can acquire the<br>character X gradually?           |

**Will of mind,  
Character of  
atomism,  
Degree of  
separateness**

**Will of physics,  
Character of  
connectionism,  
Degree of  
association**

**knowledge  
forms**

**knowledge  
attributes**



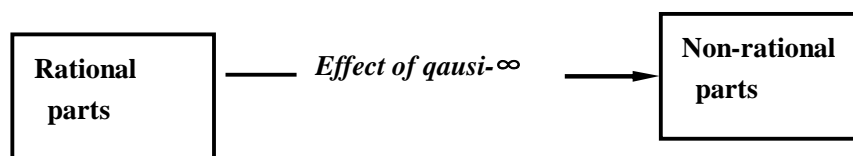


Fig. 2 Infinity or infinitesimal is a big challenge for rationality. As guessed by the author, the effect of a qausi-infinity or -infinitesimal usually is the end of a rational and the beginning of a non-rational or empiricism.

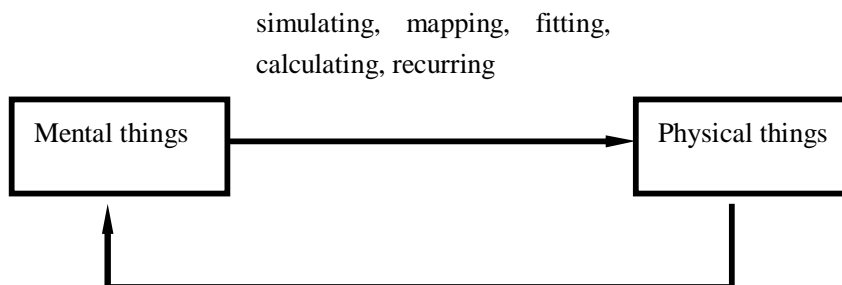


Fig. 3 The relationship between mental things and their corresponding physical ones. And they are different in nature, movement features and laws.

### 3. Big-Or Space and Associations

Although the conclusion is that reasoning processes only can effectively implement in mental systems, it means exactly the axiomatic systems or spaces like Euclidean space, rather than so called “big-or” spaces, which, as mental systems, only allow doing association, not reasoning.

The general understanding or association of the scientific knowledge are based on a “big-or” space, formed by the union operation of many different spaces:  $S=S_1 \cup S_2 \cup S_3 \cup \dots$ . When we read a textbook or listen to a lesson, our mind consciously or subconsciously and continuously move from one effective knowledge background space to another, just by the bridge-factor(s) at the intersection of two spaces. Therefore S is, as the author called, the “big-or” space.

Let's take a text from a textbook of physiology as an example. The original text is as following:

“The heart, a hollow muscular organ, is located in the center of the chest. The right and left sides of the heart each have an upper chamber (atrium), which collects blood and pumps it into a lower chamber (ventricle), which pumps blood out. To ensure that blood flows in only one direction, each ventricle has an "in" (inlet) valve and an "out" (outlet) valve.”<sup>[15]</sup>

The axes of the spaces which this text involved in are (a bit of change has been made from original text for easier understanding):

The heart, a hollow(**① combination relation of a substantial wall and two-end-opening lumen**) muscular (**①the biological material with special biologic features**) organ, is located in the center of the chest(**①the organ spacial distribution in organism and ②their orientation and adjacency relations**). The right and left sides(**① gravity field and ② sagittal plane of the body-relative orientation in Euclidean space on the earth**) of the heart each have an upper chamber (atrium) and a lower chamber (ventricle) (**①upper and lower reaches of a liquid flow; ② shape of the container; ③obstruction of a flow**), the atrium collects blood and pumps it into the ventricle, which pumps blood out. (**① two-end-opening hollow ware; ②the contractility of biological wall and pressure-transmit between wall and liquid; ③ hydrodynamics**) To ensure that blood flows in only one direction, each ventricle has an "in" (inlet) valve and an "out" (outlet) valve.( **①a mechanism of single-direction flow; ② biological half-rigid valve; ③ the size of the diameters of valves and container**).

### 4. Axiomatic Space and Reasoning

As mentioned above, BMKI has concluded that reasoning only can implement in an axiomatic space like Euclidean space. And as we have seen in Euclidean space, an axiomatic space is built up by a set of basic or axiomatic or generally accepted elements and propositions. BMKI has further concluded that an axiomatic space, its certainty, its necessity-sufficiency and if an assert comes into existence, etc are determined by a special cognitive goal. Thus the relationship chain is “cognitive goal—*determine*→axiomatic space—*determine*→if a reasoning comes into existence”. Now using a small story presented by a friend on <Medical Informatics

Forum> (or MI Forum), to explain these arguments.<sup>[16]</sup> )

The story is very simple: After dinner, the mother and the daughter were cleaning the dishwares in the kitchen, and the father and the son was watching TV in the living room. Suddenly, a clear sound of breaking dishes or bowls came from the kitchen and followed by a quiet. “Mother broke it!” the son said to the father. “How do you know?” “She didn’t blame!”

That is the whole physical scene. The cognitive goal is to judge “who broke dishwares.” To finish this cognitive role, we can’t still stay in that physical space or its shadow space ie quasi-physical space. Because as mentioned above, a physical system (or space ) is “infinite, non-prognosticated, uncertain, boundless, diverging...” We can’t image that there are maybe a cat, a dog, or an unstable dishware-shelf ... in the kitchen and they broke the dishwares. We should immediately transform the space from the physical space to a mental one to guarantee the feature of exclusivity ie “any things wouldn’t exist except those mentioned and implied”. Then we created an axiomatic space composed of the set of generally accepted rule (for that cognitive goal, of course) : ①the mother broke dishwares; ②the daughter broke dishwares; ③the mother blame the daughter; ④the daughter don’t dare to blame the mother. From the space we can reason  $① \wedge ④$  or  $② \wedge ③$ . Here evidently only  $① \wedge ④$  meets the physical scene.

As a base of reasoning, the axiomatic space usually exists underconsciously, a way to make it unveiled is:

- (1) From a “big-or” space or an uncompleted axiomatic space, we get a set of test proposition;
- (2) Check the validity or the necessity-sufficiency the set, if “yes”, then return to (6), else go down;
- (3) Analyse the causes of the invalidity and check the shortage of or confliction among those basic definitions and axioms;
- (4) Supplement or amend these basic definitions and axioms;
- (5) Return to (1);
- (6) The end.

## 5. Beacon-compass-strategy in BMKI

The BioMedical knowledge systems are the most complicated ones in the world. Where many elements, processes, mechanisms are combined together and the layers and the interrelations are anfractuous. And there are also many unknown things in them. Therefore the BioMedical knowledge systems are called by somebody “the desert of mathematics”. Although such an assert is gong to be denied currently by the development of Bio-Medical Informatics, BioMedical knowledge systems, up to now, are still the world of empirical and experimental knowledge. Logic reasoning and mathematical calculation are not the leading part of them.

The most empirical and experimental knowledge eg “blood pressure is 80/120 mmHg”, “cough at night”, etc belongs to the type of “know it is so”, rather than “know why it is so”. We have to accept them conditionlessly. The relationships in that kind of knowledge are called “mapping” in mathematics, without needing to reason labouredly. BMKI describes visually the mapping in the empirical and experimental knowledge as “dark sailing dependent on beacon(or island)”, meaning that “the captain” does not have to estimate the course of sailing according to wind-, water-flow, compass directions, etc. Contrarily, BMKI calls knowledge reasoning of theoretical knowledge eg “to reason the probability of cerebral hemorrhage from the levels of



blood pressure, blood lipid, blood viscosity, and the physical signs, symptoms, etc of a patient” as “dark sailing dependent on compass”.

As stated above, in the BioMedical knowledge integration, it is absolutely difficult without mapping. Thus the strategy to combine empirical mapping and theoretical reasoning is called the “beacon-and-compass strategy” of BioMedical knowledge integration(see Fig 6). That is the number one strategy in BMKI.

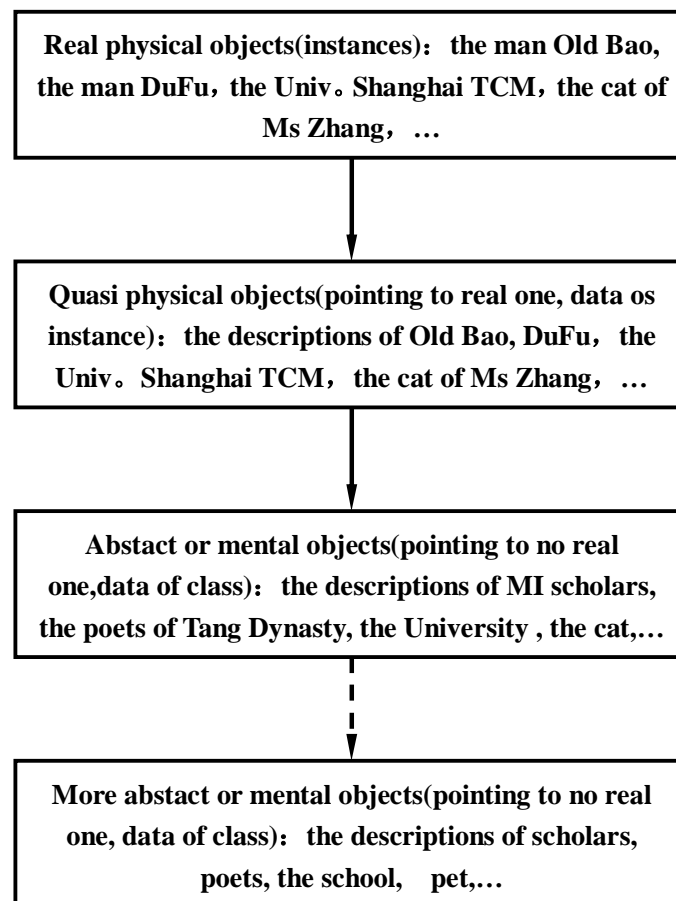


Fig. 4 The relations and examples of three types of the cognitive objects: real physical, quasi-physical, abstract or mental objects.

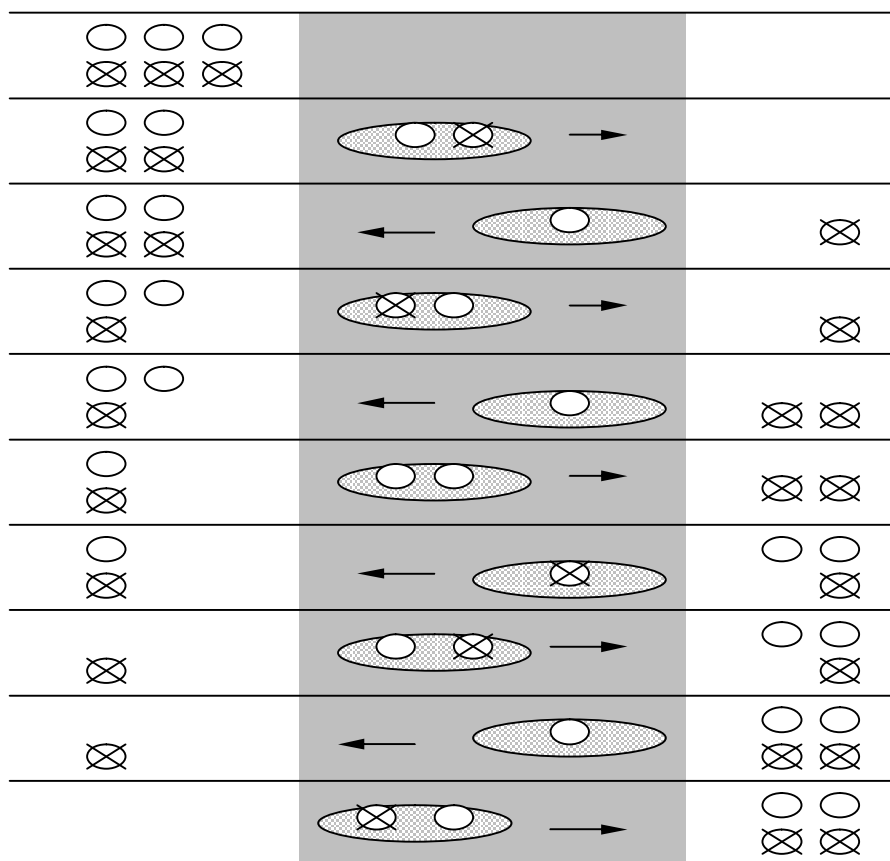


Fig.5 A solution of the story “Three priests and three human-eaters”. ○ and ⊗ are priest and human-eaters, respectively.

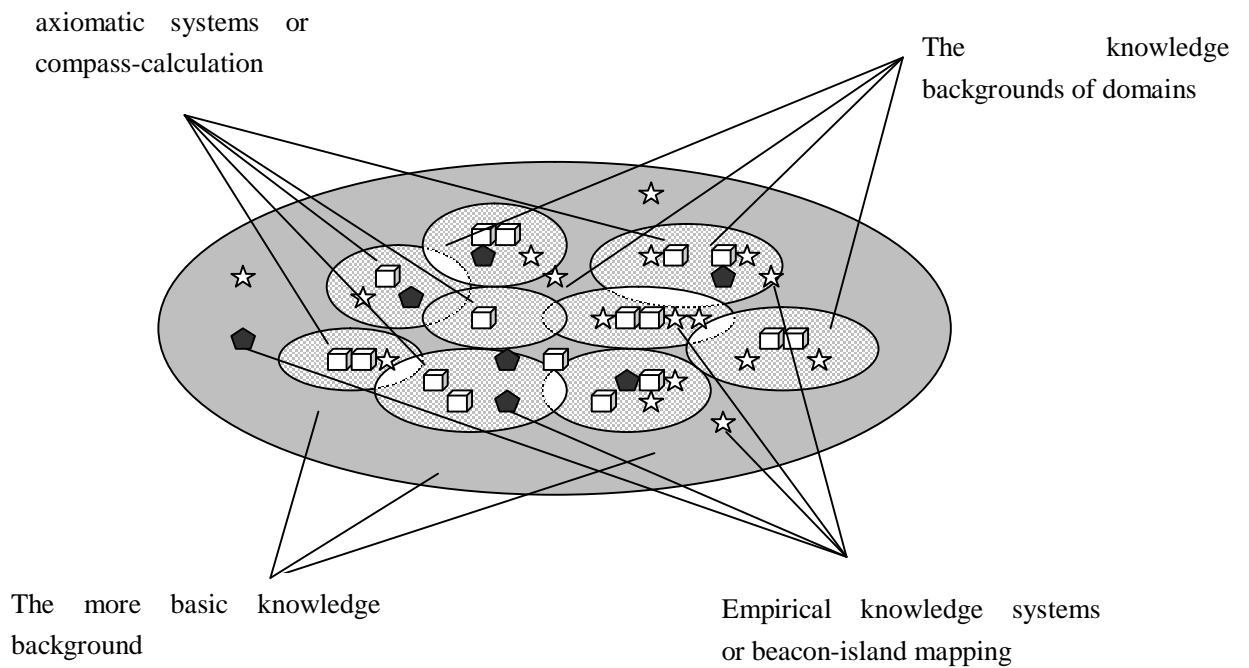


Fig. 6 A schematic diagram to show the “beacon-compass-strategy” of BioMedical knowledge integration. The white small cubes, white stars and black pentagons represent the elements/rules of axiomatic systems(compasses), beacons and islands, respectively.

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