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Structure Characteristics of QMSOC and the Relevant Operators

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Summary: This article presents a further description on the background, significance, and structure characteristics of Quantitative Medicine Simulation and Operation by Computer (QMSOC). Also some basic operators were recommended for calculations of biomedical events such as estimation of substance concentrations, exploration of etiology, evaluation of biomedical effects, etc. At last some differences of QMSOC from other artificial intelligent systems in the medical field were discussed.

Key words: mathematics, computer, diabetes, medical informatics, glucagons

Some initial ideas about the new research Quantitative Medicine Simulation and Operation by Computer (QMSOC) have been stated in previous papers [1,2] . This one is intended to give more explanation on QMSOC, including its background, significance, structure characteristics, and a set of basic operators.

1. The background and the structure characteristics of QMSOC

Differing from the traditional and predominant trend of medical researches (macro-to-micro dissection process), QMSOC puts the emphasis on quantitative integration of multi-factor, multi-subject and multi-level information, transversely and longitudinally. The background and significance of the presentation of this new research are described:

1)As the medical science is more and more branched, the traditional specialities will get more sequestered from and unacquainted with each other, and also, the ratio of the scope of the individual scientist to the entire medical information resources is acutely getting smaller.

2)There is a disagreement of the integrity of natural life with the discreteness of the information, and in the understandings resting only on the discrete knowledge, narrow-mindedness to some extent might not be avoided.

3)The mammoth amount of the information discovered through the dissecting processes must undergo the reintegrating course in order to go back to the natural and integral organisms, which dem ands much more difficult efforts than the dissection.

4)The forms by which the medical resources are edited are poorly suited for the execution of quantitative operators, such as forward-deducing and backward-tracing, outward-extending and inside-probing, branching and converging, integrating and disintegrating, and other quantitative analyses of mechanisms and causations.

5)The unbalanced pattern for science development nowadays, with information big produced but small utilized, or from a different perspective, more divided but less composed, is not an optimal one.

QMSOC takes it that via the permanent and delicate memory of computer and its high velocities of data retrievements and calculations, plus the appropriate formalization of medical resources, the challenges by the problems described above will, to some extent, be relieved, and also medicine will be operated with more mathematical and engineering sense, the diseases the patients suffer from will be monitored, investigated and treated in more accurate ways.

2.The structure characteristics of QMSOC

Designing of QMSOC has been heavily influenced by Pansystems Methodology (PM)[3-6].

Briefly speaking, QMSOC structurally takes the sets of binary quantitative relationships among factors, accompanied by their relevant conditions, as the fundamental bricks of its knowledge base, and functionally, it employs varieties of operators derived from such as the Set Theory, Discrete Mathematics and Pansystems Methodology, etc. as its running mechanisms.

The physical body of the program QMSOC is a new type information medium- the computer-supported and operational data base, which was edited in very special way termed Homo-information Coded Editing (HICE) technique. As stated above, in this data base medical knowledge has been essentially formalized by quantitative binary-relation-elements.

The data units are composed of three parts, the set of conditions(C), the set of factors (F) and the central part (R) which contains the binary relations. The factor set is referred to the life substances and the condition set to the circumstances whereby the life events are taking place, whereas the third part, i.e., the central core, connects the elements of the first two sets, serving as the key for furnishing the data base with the abilities of operation.

Resting on the roles the factors play in the biomedical events, the factors of F are categorized into three sorts. They are the main, the referential and the additional factors, being acronymized as mf, rff and adf, respectively. The mfs are the subjective factors under investigation, and the rffs are the objective ones, whose biomedical behavior could be influenced by the mfs and are, in turn, able to serve as the indicators for the actions of mfs. The additional factors (adfs) are the assistant factors which are deliberately added into the experiments, usually with dosages significantly larger than the physiological levels, to magnify the results for the detectability [1,2].

With regard to the contents, the condition set covers the items of sort (if animal), sex, age, body weight, food composition, physiological and pathological states of the subjects during the experiments, and also, the experimental protocol – the time points, the ways and dosages for administration of reagents, the methods, sites and amounts to take the samples, and the details of procedures of their post treatment for measurements and analyses, etc. The elements of condition set as well as factor set are tailed with the explanations as detailed as possible. So, in fact, both sets concurrently serve as highly specially-structured dictionaries of methodology and terminology for medical researches.

3.Some basic operators for biomedical evaluations

The following operators could be used to evaluate the behavior of the main factors (mfs) represented by the relations among the reference factors (rffs). They make it possible that in some cases the actions of mfs might be evaluated in non-experimental ways.

Operator 1

If $rff_{(1)}=F_1(rff_{(2)})$ and $rff_{(3)}=F_2(rff_{(2)})$, both under conditions C, and both F_1 and F_2 are the functions of one-to-one projections, then

$rff_{(1)}=F_1 \circ F_2^{-1}(rff_{(3)})$. This operator can be used for indirectly evaluation of the concentrations of some factors, such as the concentrations of substances, etc.

Operator 2

Let C_m, C_n, and C be the condition sets and $C= C_m \cup C_n$. If the experimental established binary relations are $rff_{(j)}=F_m(rff_{(i)})$ and $rff_{(j)}=F(rff_{(i)})$, under C_m and C, respectively, then the effect of C_n on C_m in this case is able to be expressed as

$F=drff_{(j)}=F(rff_{(i)})-F_m(rff_{(i)})$. This operator leads to the next operator.

Operator 3

If $C_1 \subset C_2 \subset \ldots \subset C_n$ and

$rff_{(j)}=F_1(rff_{(i)})$, under C_1,

$rff_{(j)}=F_2(rff_{(i)})$, under C_2,

…

$rff_{(j)}=F_n(rff_{(2)})$, under C_n,

and $C_d=C_{n1}-C_{n2}$, $n_1 \neq n_2$, $C_{n2} \subset C_{n1}$, then the influence of the condition set C_d on the binary relation of $rff_{(i)}$ with $rff_{(j)}$, in the case C_d being added to C_{n2}, is

$F=D_{d-n2}(rff_{(j)})=F_{n1}(rff_{(i)})-F_{n2}(rff_{(i)})$.

This operator could be utilized for evaluating the biomedical effects of certain supplementary conditions.

Operator 4

If under C, $rff_{(i)}=F_1(rff_{(j)})$, and $rff_{(j)}=F_2(rff_{(n)})$, then $rff_{(i)}=F_1 \circ F_2(rff_{(n)})$, the necessary prerequisite is only that C is kept unchanged.

This operator could be applied to auto-evaluate, for example, the levels of certain factors and to find, if any, possible unknown phenomena.

Operator 5

If $rff_{(i)}=F_1(rff_{(j)})$, $rff_{(j)}=F_2(rff_{(n)})$ and $rff_{(i)}=F(rff_{(n)})$ were established under condition sets C_1, C_2 and C, respectively, where $C=C_1 \cup C_2$, then the influence of the interaction between C_1 and C_2 in union set C on $rff_{(i)}$, $rff_{(j)}$ and $rff_{(n)}$ is $drff_{(i)}= F_1 \circ F_2(rff_{(n)})-F(rff_{(n)})$.

Operator 6

If we have confirmed the relations $rff_{(j)}=F_m(rff_{(i)})$, under C_m and $rff_{(j)}=F_e(rff_{(i)})$, under C_e, and $C_n \subset C_m$, and $C_n \subset C_e$. Let $C_{dmn}=C_m-C_n$ and $C_{den}=C_e-C_n$, then the difference in the biomedical performance of C_n, the common part of C_e and C_m, when added to C_{den} and C_{dmn} can be evaluated by the equation $F=drff_{(j)}=F_e(rff_{(i)})-F_m(rff_{(i)})$. This operator can be used for evaluation of the differences in the biomedical behavior of some condition sets in non-experimental way.

Operator 7

We have relations

$rff_{(2)}=F_1(rff_{(1)})$, under C_1,

$rff_{(3)}=F_2(rff_{(2)})$, under C_2,

…

$rff_{(n+1)}=F_n(rff_{(n)})$, under C_n,

and $C_{2,1}=C_2 \cup C_1$,

$C_{3,1}= C_3 \cup C_2 \cup C_1$,

$C_{4,1}= C_4 \cup C_3 \cup C_2 \cup C_1$,

…

$C_{n,1}= C_n \cup C_{n-1} \cup \cdots \cup C_1$. We have also found

$rff_{(3)}= F_{3,1}(rff_{(1)})=F_2 \circ F_1(rff_{(1)})$,

$rff_{(4)}= F_{4,1}(rff_{(1)})= F_3 \circ F_2 \circ F_1(rff_{(1)})$,

…

$rff_{(n+1)}= F_{n,1}(rff_{(1)})= F_n \circ F_{n-1} \circ \cdots \circ F_1(rff_{(1)})$.Then it will be true that the mechanisms of F_1,F_2, …,Fn are independent of each other and the cause-result chain from $rff_{(1)}$, through $rff_{(2)}$, $rff_{(3)}$, …, to $rff_{(n+1)}$ is, only under this condition transmissibility-transparent. Otherwise, we should say that there must be some new mechanisms created because of the unions of C_1, C_2, …, C_n.

Operator 8

If $rff_{(1)}$ is, for under both $C_{(i)}$ and $C_{(j)}$, the only source for two factors $rff_{(2)}$ and $rff_{(3)}$, and additionally, the latter two factors are the only users of the first one, and the established relations under $C_{(i)}$ are $rff_{(2)}=F_{2i}$ $(rff_{(1)})$ and $rff_{(3)}=F_{3i}(rff_{(1)})$ then in the case of $C_{(j)}$, the observation $F_{2j}(rff_{(1)})-F_{2i}(rff_{(1)}>0$ will arrive at a conclusion $F_{3j}(rff_{(1)})-F_{3i}(rff_{(1)})<0$, the prerequisite is the ratios of input/output being kept constant.

Operator 9

If $rff_{(j)}=F(rff_{(i)})$ is the determined relation under both C_m and C_n, $C_n \subset C_m$, $C_d=C_m-C_n$, $C_d \neq \Phi$, then it can be concluded that F is independent of C_d or, in this case, the net effect of C_d on F is zero. This operator could be employed to exclude the condition subsets which are, in fact, without pathological meanings for some relations, or with a total effect of the subset being equal to zero.

Operator 10

Let $X_{(i)}$, $X_{(j)}$ and X be three given levels of $rff_{(i)}$. If the known binary relationship between $rff_{(i)}$ and $rff_{(j)}$ is $rff_{(j)}=F(rff_{(j)})$ and it is assumed that $X_{(i)} \leq X \leq X_{(j)}$ and $X_{(j)} - X_{(i)}$ is small enough, then

$Y=F(X)=F(X_{(i)})+(F(X_{(j)})-F(X_{(i)})/(|X_{(j)}-X_{(i)}|)*(X-X_{(i)})$

Where Y is the level of $rff_{(j)}$, corresponding to X.

If not the case, than it is reasonably recommended to check whether there exist turning points in the domain between $X_{(i)}$ and $X_{(j)}$ for the binary relationship.

This is a well accepted and commonly used operator for the linear portions of relations in the biomedical field.

In the text above, symbols F, F^{-1}, $\circ$, $\cup$, $\subset$, and Φ represent the functions (relations), inverse function (inverse relation), composition, union, being contained, and empty set, respectively.

DISCUSSION

QMSOC in many aspects in different from other medical artificial intelligent systems such as Expert Systems [7,8] and Diagnostic Encyclopaedia [9]. One point is that its knowledgement base as well as the decisions made are, in principle, independent of doctor's experiences. Another point is that its emphasis has been laid on quantitative understanding of the mechanisms of integrated biomedical events, with the secondary functions to support clinical and laboratory activities, whereas the Expert Systems and Diagnostic Encyclopaedia are characterized by the involvement of doctor's opinions and their practice-serving purpose in clinical affairs.

In addition to those operators presented, other developments newly achieved in QMSOC include:

1.The size of data-base-model on diabetes and glucagons has been doubled;

2.A small tool-kit for HICE, with functions such as automatically number-updating and nature-labeling of the data elements, has been developed;

3.The small operative system has been completed. It possesses the functions of data processing, for instances, auto-searching, -retrieving and –showing of the objective factors and their quantitative relations and relevant conditions. Finally, the binary relations are shown graphically.

The forthcoming works include providing the system with some fundamental operation functions.

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