Theory of Biomedical Knowledge Integration(V)

——The meta-dimensions and their combinations of the General Linkage/Modifiers of SNOMED

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Abstract   From the integrated view of cognitive and noetic sciences,   a set of meta-dimensions and their combinations, covering almost all of general linkage and modifiers of SNOMED, has been presented. Some examples for reasoning and operating for this set have been illustrated. Therefore the article has proved theoretically that it is possible to significantly increase the abilities of reasoning or operating and being-understood by computer in data mining of EMR, etc for a terminology system including relation(or linkage) or restriction (or modifier) items such as SNOMED. Additionally, an important principle of cognitive science, ie so called the non-rational linking principle between the knowledge in dimensionally different spaces, has been presented in this paper.

Key words   Medical Informatics   Artificial Intelligence   The Theory of Bio-Medical Informatics(BMKI)   SNOMED

There are nowadays numerous   researches and developments at knowledge or clinical levels in Medical Informatics such as the terminologies, taxologies, ontologies, etc and they have won and will further win much or more admirations from these fields. But there are still a lot of basic questions   needed to be clarified ,   and otherwise, as the author believes, the effectivities of those excellent works will be extremely limited.

Besides, Medical Informatics(MI) needs the theories of itself, ie additional to those theories borrowed from other fields such as the Informatics in general sense, AI, etc. the MI needs the informatics that organisms themselves tell us.

This work is intended   to picture out the logical (not physical yet) structure for the chapter of General Linkage/Modifiers of SNOMED which will play an important role in composition of EMR. And, consequently, it is expected   to enhance their abilities of operation, calculation and easily-being-"understood" by computer. The research is based on the meta-dimensions and their combinations of those linkages and modifiers.

1. How to Achieve the Goals

So called meta-relations or meta-dimensions are those atomic ones, ie which can be no more spilt into the more basic ones. In addition, they are usually independent of each other and the atomic elements or units of logical or thinking processes.

In general, we may operate or calculate the relations(or linkages) and attributes (or modifiers) of or between the things by the means or mechanisms as followings:

1.   the logic implications between them;

2.splitting them into their meta-relations, meta-attributes(or meta-dimensions) at various levels, ie anatomizing-and-then-recombining them, through which they may get more detailed granularity and given more concrete values.

3.   evaluating the General Linkage and Modifiers;

4.   various physical relations between the things or their attributes, eg. generation relation, and other causalities.

The paper is trying to apply the former three mechanisms to attain the objectives and, as the essential step, to anatomize, recombine and reorganize the series of general linkage and modifiers of SNOMED in view of   the logical, cognitive or thinking processes rather than the application aspects.

2. The New Concepts of Space

The most difficult point for this purpose is the fact that many objects in the bio-medical fields exist in a very special space of organism, which is a space naturely different from those spaces in common sense.

For making the questions more clear, let's go back to some where very beginning.

1)   What is the informatics the organisms tell us

As mentioned above, there are in the area of knowledge engineering of Medical Informatics   a lot of new principles, methods introduced from the fields of

artificial intelligence, cognitive sciences, logics, etc. such as production system, frame system(eg ontologies), semantic network, neural network, etc. All of these stories however, except neural network which is enlightened by the working forms of neural system, are from the general systems rather than the very special systems, ie the organisms which is the target systems dealt with by Medicine. Then what are the stories of informatics which the organisms themselves tell us? People in Medical Informatics seem to have no answers so far. To make a train of thought for this question, perhaps we can start the explorations with some logic deficiencies of **Euclidean**Geometry, to see how complex problems we are to meet on our way.

2) The logical deficiencies of **Euclidean**Geometry

In **Euclidean**Geometry, we are told that 'point' might be regarded as zero-dimensional space and it has no length, width and height; The inertia movement of a point creates the 'line', which is one-dimensional space and has no width and height but length; And, in turn, the inertia movement of a line creates the 'plane', which is two-dimensional space and has no height but width and length; And at last we have a 'cube' through the inertia movement of a plane and it is a three-dimensional space.

The problems are, as also doubted by another famous mathematician Pythagoras, as defined, a point has no length, why its inertia movement can make length? And as the same, why the inertia movements of a line without width and a plane without height can create area and volume, respectively?

For those obvious logic gaps, Euclid didn't give out any answers, perhaps because the empirical or physical knowledge tells him they are true. Whereas this fact leaked out to us a big secret of human thinking mechanism: the transformations between the knowledge in the essentially different spaces (ie the dimensions of them are different and independent of each other) are non-rational, or empirical or physical(perhaps because there are always involved in the questions of infinity in logics, as pointed out in a paper of the author's[14]), hence, which is an important principle of cognitive science presented by **the** Theory of Bio-Medical Knowledge Integration(BMKI)[1-14], is called the non-rational linking principle between the knowledge in dimensionally different spaces.

And it is the cornerstone of the theory of **Euclidean-like space which will be** introduced at the following text and so called Compass-Beacon Strategy(CBS) of BMKI. It seems to conflict with the main direction of somewhat reductionism[15] in this article, about this never-stopped academic argument, the author would like to explore in other cases.

Totally speaking, Euclidean Space(ES) is the traditional or mathematic space, which is the formalized-space or the space in pure mental world, with nothing substantial in it. Whereas the Euclidean-like-spaces(ELS) are substantial ones, ie the spaces in real world. According to the degree of organization, they have the primarily subdivided types and the order as: General or substantial Euclidean-like Space→Euclidean-like Space of organic substance→Euclidean-like Space of bio-macromolecule→Euclidean-like Space of organism.

3. The Set of Meta-dimensions and their combinations

of the General Linkage and Modifiers OF SNOMED

The new organization   presented here covered almost all the general linkage and modifiers in the book edited by Roger A. Cote and translated (into Chinese) by Li Ensheng(College of American Pathologists, 1993)[16]. The levels where reflect the implication relations or whole-part relations, A*B means the combination of A and B, symbol '→' indicates the logical order of the cognitive processes, and the coded items are the examples of   the corresponding ones from that book, and the author believes that the positions of them in the frame are sometimes context-determined. According to the principle of non-rational transformation between the knowledge in the different spaces originated by BMKI,   a set   of Euclidean-like space(ELS) has been introduced.

Part 1   Cognitive attributes(The dimensions directly related with cognitive actions):

I.   Cognitive attribute: (Desire→ advantages-and-disadvantages→ likes-and-dislikes)

       1. Desire: G-4006 (Requested by patient)

       2.Advantages-and-disadvantages: G-4040(Risk of),G-4043   (High risk of),

       3. Likes-and-dislikes: G-A249(Benjgn), G-A222(Bad),

       4. Certainty : G-A385（Indeterminate）, G-A386(Determinate),

       5. Granularity: G-A456 (Clear),G-A627 (Vague),

       6..Cognitive actions:

           A).Observation-and-result:

               1)Observability:G-A389(Occult), G-A614 (Invisible),

           B).Perception→Be-aware-of→Recognition→Interpretation: G-A464 (Known)

           C).Comparison→Identification-descrimination: G-A352 (Discriminate), G-A353 (Indiscriminate)

           D)Judgement-or- diagnostic:

               1)Judgement*time: G-1001 (Prior diagnosis),G-1004(Working diagnosis),

2)Judgement*existence-population-frequency:G-1002 (Admitting diagnosis),

               3)Judgement*cognitive-process-stage: G-1003(Preliminary diagnosis),G-1017(Final diagnosis)

4)Judgement*cognitive-process:G-1005(Revised diagnosis)

5)Judgement*identification-descrimination:G-1006(Differential diagnosis),
6)Judgement*mainjoriy-minority:G-1007(Principal diagnosis), G-1008(Secondary diagnosis)
7)Judgement*certainity:G-1009 (Established diagnosis), G-2001(Suspected diagnosis),
8)Judgement*intervention-method: G-1010 (Clinical diagnosis),G-1011 (Laboratory diagnosis),G-1012(Cytology diagnosis),
9)Judgement*object-process-stage: G-1016(Death diagnosis),
10)Judgement*major-minor *causality*object-process-stage: G-1016 (Major cause of death)
E).Abstraction(generalization)(→classification): G-A366 (Generalized, General),
1) Contain-or-coverage:G-A655 (Containing),
F). Calculation-or-operator: G-A226(Double),G-A227(Triple),
G). Intervention：
1) Existence-of-intervention: G-4007(Received therapy or drug for),G-4008 (Did not receive therapy of drug for)
2) Methodology-of-intervention: G-A260(Inoperable),G-A261(Operable)
3) Effect-of-intervention：
G-A400(Intractable),G-A503 (Refractory), G-A635 (Effective)
H) Cognitive domain:G-A304(Clinical) ,G-A305(Subclinical)

Part 2   The existence-level dimensions

I   Nature of existence:
    1. mental-or-physical thing:
    2. attributes of motion-or-motionless:
            A).static thing:
        B).dynamic thing:
                1)motility:G-A266 (Changing).
            a) process:
                    i)phase of process: G-A604 (Phase).

ELS-of-organism*phase-of-process：G-A392 (Infantile), G-A380 (Incipient), G-A020 (Early, Early stage), G-A021 (Midstage),G-A022 (Late, Late stage), G-A023 (End-stage,Terminal stage,Final,Final stang).
                    ii)morphology-of-process:

circle: process*repeatability:
G-7150(Periodic).

               switching-form:
b) rate(=size-of-change/time）: G-A231(Acute).
      i)rate*morphology*ELS-of-organism：
G-A273 (Chronic granulomatous).

    c)direction: G-A253 (Monophasic), G-A512
(Reversible).

    d)energy-or-potential:
        i)potential: G-A230 (Active).
        ii)inertia): G-A538 (Habitual).
        iii)function:
            physiological function:
G-A264(Calcified).

            pathologic function:
G-A238(Anicteric),G-A254(Bleeding).

    3.stability: G-A553 (Stable).

    4. continuity-discontinuity: G-A480 (Persistent), G-A397)(Intermittent).
        A).continuity-discontinuity*degree* motility: G-A236(Advanced).

    5.co-existence(number-existence)：
        A).simplicity:G-A537 (Simple).

B).multiple-occurrence-or-multiple-state-switching):G-A323(Dimorphic), G-A644 (Concurrent).
        C).compositeness:G-A291(Compound), G-A283 (Combined).

    6. existence-frequency-or-repeatability:(existence-frequency =existence-number/size-of-domain-or-time): G-A248(Atypical), G-A308 (Common).
        A).repeatability*time:G-A403 (Regular), G-A468 (Paroxysmal).
        B).normal-abnormal(=repeatability*population): G-A460 （Normal）,G-A210 (Abnormal).

II   Background space:
    1.**Euclidean Space(ES)**:
        A) Distance-in-ES: G-A178 (Remote).
        B) Structurein-ES:G-A148 (Linear), G-A131(Triangular).
    2. **Euclidean-like-space(ELS**):
        A)   General or substantial **Euclidean-like Space(ELSG)**：G-A358(Fascicular)
G-A370(Granular), G-A371 (Guttate), G-A322(Digitate).
        B)   **Euclidean-like Space of** bio-macromolecule(ELSBG):
G-A431 (Membranous).
            1) (General or substantial **Euclidean-like Space**）*size：G-A617（Thick）, G-A221 (Thin)
            2) Site-in-GELS): G-A165 (Site), G-A166 (Area), G-A167 (Regional, Region).

C) **Euclidean-like Space of organism(ELSO):**

    1) ELSO*Surface-space-of-earth：G-A419 (Postural).

    2) ELSO*Anatomic-structure:G-A587 (Vascular).

    3) ELSO*Physiological-function: G-A569 (Tactile).

    4) ELSO*Morphology-of-structure: G-A448 (Nodular),G-A469 (Papillary)'

    5) ELSO*Morphology-of-pathological-structure: G-A521 (Rupial), G-A624（Bullous）.

    6) ELSO*Pathological-mechanism:G-A557 (Strangulated).

    7) ELSO*Pathological-function: G-A398 (Internal blind), G-A341 （External blind）.

III.   Time:

    Duration of the existence of a thing: G-A577 (Transient), G-A578 (Transitory,   Temporary), G-A541 (Permanent).

    Comparison between the occurrence times of two things: G-4003 (Status pre-, Prior to),), G-4004 (Status post,   After), G-A491 （Postprandial）.

    Comparison between the occurrence time of a thing and current : G-A176(Previous), G-7160 (Recent), G-0001 (History of), G-0003 (Past history of), G-0006 (No history of), G-0008 (No past history of).

    Period between two things：G-A377 (Immediate).

    Time*change: G-A318 (Delayed).

IV.   Measurement:

    1. Size, G-A340(Extensive).

    2. Degree: G-A001(Mild).

    A)   Comparison* size: G-A437 (Maximal),

    B)   Size*motility: G-A336(Expanding), G-A337(Shrinking), G-A316 (Decreased),Diminished), G-A317(Increased), G-A599 (Ascending), G-A600   (Descending), G-A616 (Elevated).

    C)   Degree*like-dislike:G-A003(Severe).

    D)   Degree*motility: G-A499   (Regressive).

    E)   Degree*motility*Whole-part-relation:G-A004 (In partial remission, Incomplete remission).

V. General-attributes-of-substance: G-A357 (Desiccated, Desiccating, Desiccative), G-A388 (Hard), G-A592 (Wet,   Moist, Damp, Humid).

VI   Morphology:

VII   Function：G-A365 （Functional），G-A451 （Non-functional）.

VIII   Natural-artificial: G-A246(Artificial),G-A447   (Natural)

Part 3   The relation-level dimension

I. Relations:
      1. Positive-or-negative-existence-of-relation:
            A)   Positive existence: G-A657 (Involved, Involved).
            B)   Negative existence: G-A628 (Isolated) , G-A658 (Uninvolved,
Not involving).
      2. Cognitive attribute:
        A)   Cognitive action:
              1)   Comparison-or-control: G-A474 (Controlled), G-A475
  (Uncontrolled).
Comparison→ Identity-distinction→ Border→ Contiguity:
      3.   Identity-distinction:G-A422 (Identical),G-A213 (Unequal,Inequality of),
G-A214 (Equal).
            A)   Identity-distinction*repeatablity: G-A403 (Regular), G-A402
(Irregular).
            B)   Identity-distinction*morphology: G-A404（Isomorphous,
Isomorphic）,G-A239(Anisomorphous).
      4.   Border： G-A428（Margina）， G-A262（Borderline）, G-A428
（Marginal）,G-A173(Straddling).
            A)   Border*certainty:G-A262（Borderline）.
            B)   Boder*motility:G-A174(Along edge).
     5.   Contiguity:G-A426 (Contiguous).
     6.   Inside-outside: G-A112 (External,Outer,Outside);G-A113
(Internal,Inner,Inside),
            A)   Inside-outside*transporting: G-A127 (Afferent) , G-A128
(Efferent), G-A486 (Patent, Open , Opening).
            B)
Inside-outside*transporting*structure-in-genral--space:G-A170(Portal, Hilar, Hilus),
G-A315(Satellite).
            C)   Inside-outside*generation: G-A334 (Endogenous),
G-A335(Exogenous).
      7.   Majority-minority: G-A332(Principal, Main, Primary), G-A607
(Predominate, Predominately), G-A331 (Essential).
            A)   Majority-minority* inside-outside:G-A125 (Circumferential,
Surrounding),   G-A111 (Peripheral).
      8.   Element-number-involved-in-relation：
            A)   Double-element-relation:
            B)   Triple-element-relation:
            C)   Multiple-element-relation:

II   Inside-relations:

1. Whole-part-relation：G-A381(Incomplete, Partial), G-A175(Sectional), G-A396(Intact), G-A629 (Sufficient), G-A290 (Complete, In toto, Total, All).

    A). Whole-part-relation*pathological-function: G-A382(Incomplete blind).

    B) Whole-part-relation*site-in-general-space: G-A417 (Local, Localized , Topical, Limited area).

2. Inside-outside*relative-relation-in-KLS-of-organism: G-A107 (Cephalic, Cephalad, Rostral), G-A108 (Caudal, Caudad); G-A109 (Medial, Middle, Median); G-A110 (Central, Center).

3. Partition: G-A548 (Splitting).

4. Generation*inside-outside*process): G-A549 (Spontaneous).

III   Outside-relation:

1. Element-number-involved-in-relation：

    A) Double-element-relation*relative-relation-in-KLS:G-A129 (Juxta-posed , Adjacent, Juxta-, Adjacent to,), G-A118 (Proximal, Near to, Neighbor of,),G-A119(Distal, Far from), G-A115 (Inferior, Below, Sub-, Subjacent, Downward, Under, Down, Beneath, Infra-), G-A116 (Superior, Up, Upper, Upward, Supra-, Above ， G-A100 (Right, Dextro, Right lateral,),G-A101(Left, Levo-, Left lateral),G-A102 (Right and left, Both sides, Bilateral, Both),G-A103 (Unilateral, One-sided,),G-A104 (Lateral,),G-A105 (Anterior, Forward, Front of, Ventral),G-A106 (Posterior, Behind, Retro- ,Backward, Dorsal, Back of).

    B) Triple-element-relation*relative-relation-in-KLS): G-A114 (Intermediate, Between, Inter-, In between).

    C) Multiple-element-relation*order-relation: G-A570 (Secondary), G-A571 (Tertiary).

2. Causality：G-A391 (Induced), G-A361 (Evoked, Provoked)

    A) Generation:

        a） Lineage:

            i) Lineage*observation-result: G-0002 (Family history of), G-0007 (No family history of).

    B) Activation-inhibition: G-A564 (Suppressive, Suppressed).

    C) Reaction: G-A497 (Reactive), G-A510 (Responsive).

3. Contact-relation: G-4020(Exposure to, Exposed, Exposed to), G-4022 (Contact with).

4. Reachability-relation(→ displacement)：

    A) Existence-or-nature-of-reachability: G-A284 (Communicating), G-A453 (Non-infiltrating), G-A454 (Non-invasive), G-A455 (Non-obstructive), G-A450 (Non-exudatibve), G-A449 (Non-communicating), G-A421 (Contaminated), G-A413 (Leaking),G-A488 (Permeable), G-A489 (Non-permeable)，G-A241 (Arrested), G-A252(Blocking).

    B) Reachability*repeatability: G-A504 (Reinfected, Reinfection of).

    C) Reachability*inside-outside):G-A279 (Closed).

D)

Reaching-relation*inside-outside*advantages-and-disadvantages：G-A423
（Invasive）.

E)　Reachability*methodology:

5.　Coordination-or-consistency: G-A581 (Uniform), G-A467 (Paradoxical), G-A611 (Identified), G-A535 (Disproportionate),　G-A536 (Proportional, Proportionate).

4. The Examples to Show the Meta-Dimension Operations

1.　Reasoning:

The examples here are:

If the advantages-and-disadvantages < 0, then G-A236*G-A380*sth--*worse than--*G-A236* G-A020*sath—*is worse than--*G-A236* G-A021*sath—*is worse than--*G-A236* G-A022*sath-*is -worse than--*G-A236* G-A023*sath. Where "sth means something" and sath means "this sth is the same as the former sth".

From the relations: desire→likes-and-dislikes→advantages-and-disadvantages, we have:

If advantages-and-disadvantages< 0, then likes-and-dislikes < 0, and in turn, desire < 0(against the desire). For instance,　if G-4043 then G-A222.

2. More detailed or concretely understood　by computer:

The examples are:

If sth is G-A403, Then the more detailed or concreted understanding for it is the identity-distinction > 0 and repeatability > 0 and　If sth is G-A402, Then its identity-distinction < 0 and repeatability > 0.

If sth is G-A423, then it is reaching-relation > 0 and inside-outside < 0 (ie from outside to inside) and advantages-and-disadvantages < 0 (ie being disadvantageous)

If advantages-and-disadvantages < 0, then (reaching-relation < 0)*sth—*is better than--*(reaching-relation > 0)*sath.

If it is G-1003, then we can know more detailed: it is a judgement and the stage of　cognition-prossess ,and the value of the latter = 1(assuming the first stage be the start of cognition-process).

If it is G-1016, then we can know more detailed: it　is a judgement and the stage of　life-prossess, and the value of the latter = 10(assuming 10th stage be the terminating of life-process).

3. Judgement:

For example the granularity of G-A456*sth > the granularity of G-A627*sath .

5. Discussion

From the integrated view of cognitive and noetic sciences, a set of meta-dimensions and their combinations, covering almost all of general linkage and modifiers of SNOMED, has been presented. Some examples for reasoning and operating for this set have been illustrated. Therefore the article has proved theoretically that it is possible to significantly increase the abilities of reasoning or operating and being-understood by computer in data mining of EMR, etc for a terminology system including relation(or linkage) or restriction (or modifier) items such as SNOMED, and GALEN etc[17]. It is believed also the realizations of these tasks expected by this article are not difficult in technologic aspects for the modern software and data base technologies and the good IT engineers.

The exploration and development of the meta-dimension frame for the terminologies and taxologies will substantially increase the capacities of automatic operation, data mining and knowledge discoveries etc. of the terminologies and taxologies themselves and their supporting or possibly supporting domain or concept standards(such as ontologies) and event standards (such as HL7), and the last dada or knowledge forms such as dada base, knowledge base or fact base (such as EMR). That is the meta-dimensions construct the bottom stones for the whole supporting scheme(See Fig. 1) .Otherwise the author believe that the research has its theoretical values and the general enlightening meanings.

It is, however, a primary experiment for this purpose, let's wait for the more profounded, religious and perfect works to come.
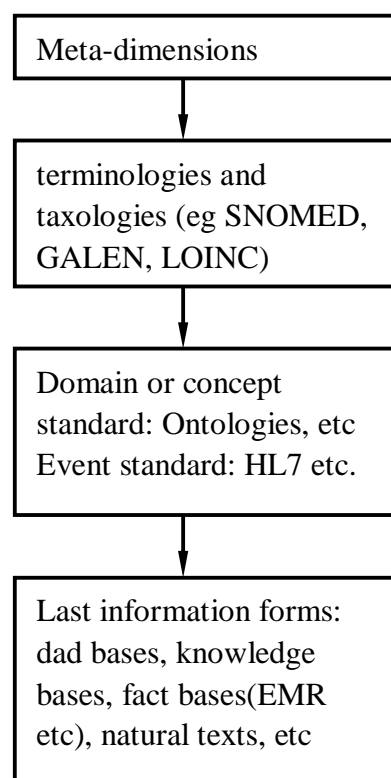
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│   Meta-dimensions       │
└─────────────────────────┘
            │
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┌─────────────────────────┐
│ terminologies and       │
│ taxologies (eg SNOMED,  │
│ GALEN, LOINC)           │
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┌─────────────────────────┐
│ Domain or concept       │
│ standard: Ontologies, etc│
│ Event standard: HL7 etc.│
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│ Last information forms:  │
│ dad bases, knowledge    │
│ bases, fact bases(EMR   │
│ etc), natural texts, etc │
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Fig. 1 The scheme for supporting relationships(arrows) between the levels of standard

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