EkviMed

A clinical model V: A clinical problem space.

Carl-Fredrik Bassøe

Abstract

Background

The immense breadth and depth of clinical medicine is an obstacle for a systematic classification of diseases and creates problems for clinical decision-making. Constructing diagnoses from well-defined components may generate systematic diagnoses. Such a construction may be achieved by using vector algebra. Decomposing systematic diagnoses in a clinical problem space gives a measure of the complexity of clinical decision-making (CDM).

Results

An empirical clinical model (CM) and vector algebra is used to design a clinical problem space (CPS). Diagnoses are vectors in CPS. The basis of CPS is created by orthogonal dimensions etiology **E**, disorders **O** and pathogenesis **P**. Systematic diagnoses **d** are constructed by the vector **d**=**e**+**o**+**p** where **e**, **o** and **p** are vectors along **E**, **O** and **P**, respectively. A typical example is **e**=**'Bacterial** ', **o**='**cyst'** and **p**=**'itis'**, which by **d**=**e**+**o**+**p** gives rise to the diagnosis **d**=**'Bacterial cystitis'**. The structure of each dimension is described, and disorders are systematically refined in agreement with CM. Diagnoses **d** represent the underlying clinical findings and point to lacking information. Accordingly, the vector **d**=**e**+**o**+**p** opens for systematic checks of the accuracy and precision of diagnoses. A combinatorial classification derived from CPS shows that there are at least $1{,}9 \times 10^{10}$ possible systematic diagnoses. The huge size of CPS explains why CDM is viewed as a complex process. CPS is versatile and scales well.

Conclusions

The vector **d**=**e**+**o**+**p** generates systematic diagnoses in CPS. Decomposition of the diagnosis vector proves that **d**=**e**+**o**+**p** simplifies CDM by several orders of magnitude. The simplification opens CDM to a wide audience. CPS is suited for the development of computerized clinical classifications, decision support systems and medical education.

Background

A diagnosis is the end point of clinical decision-making (CDM). Diagnoses provide the basis for therapy, follow up and control, and clinical research. Clearly, diagnoses are essential to clinical practice and medical science. The explosive expansion of medical knowledge attests to the immense complexity human beings, their environment and the interaction between the two. The complexity of diseases and disorders mirror that of health.

Many problems can be solved in a problem space (Newell 1976). The structure of the space affects the efficiency of problem-solving methods. Medical textbooks make up the student's diagnostic problem space but presents medical facts in linear order. A (fuzzy) input vector representing the variables of a sick person can provide a diagnosis (Bassøe 1995a, Bellamy 1997). However, a general clinical problem space (CPS) is unavailable.

According to (Hesslow 1993) there is “no biomedical theory in which disease appears as a theoretical entity and there are no laws or generalizations linking disease to other variables”. However, a clinical model (CM) (Bassøe 1978, 1981, 1985a, 1985b, 1985c, 1985d, 1986, 1988, 2007a, 2007b, 2009, 2019, 2019a, 2019c, Hammond 1988) and the diagnosis formula d:=e&o&p (Bassøe 2019b) suggests that the diagnosis vector **d**=**e**+**o**+**p** may model diagnoses in CPS.

The complexity of diagnoses can be judged by looking through clinical classifications. By 2015 there were over 160 terminologies in the Unified Medical Language System (UMLS) Metathesaurus with over 2-million distinct Concept Unique Identifiers (CUIs) and over 6-million distinct strings related to health and medicine (Curé 2015). This suggests that the number of medical diagnosis is very high. In contrast, the number of diagnoses in 10^{th} International Classification of Diseases (ICD-10 2015) and International Classification of Primary Care 2 (ICPC-2) (ICPC-2 2015) is about 13.000. Accordingly, ICD-10 and ICPC-2 only use a fraction of the diagnoses available in UMLS and CUIs. Furthermore, the about 23.000 structural genes comprises only 2–3 % of the genome (Chowdhury 2917), suggesting that there is far more than 23.000 gene disorders. Even the number of possible genetic disorders is significantly higher than the number of diagnoses available in ICD-10 and ICPC-2.

Primary care (PC) physicians encounter numerous common and a few rare diseases and disorders. They deal with complex CDM on a daily basis, but the complexity seems to be hidden tacit knowledge that is not expressed explicitly and not translated into systematic CDM and classification. On the other hand, specialists deal with details of subtle medical problems ranging from organs to molecules. However, when given the opportunity to craft diagnoses themselves PC physicians and specialists in private praxis do not create many new diagnoses beyond those found in ICPC-2 (Botsis 2010). This suggests that physicians do not use the biomedical information available to CDM.

The breadth of PC and the depth specialist practice are important issues in the development terminologies, CDM, decision support systems (DSS), and for intelligent data entering and retrieval (Rector 2007). This study is the first to design a CPS on the basis of CM to and to construct diagnoses vectors **d**=**e**+**o**+**p**. CPS is used to analyze the complexity of CDM and advice the development of computerized DSS. We start by describing CPS.

References

Adams RA, Essex C. Calculus. Toronto: Pearson; 2013. p. 564-667.

Agur A, Dalley AF. Grant’s atlas of anatomy. Baltimore: Lippincott; 2005.

Barr M, Wells C. Category theory for computing science. New York: Prentice Hall; 1990.

Bassøe C-F. Disease compendium for physiotherapists. Norwegian State Physiotherapy School, Bergen, 1978.

Bassøe C-F. A diagnostic system based on combinatorics. Proceedings of the 4th Nordic Congress in Primary Health Care, Bergen, 1981.

Bassøe C-F. Combinatorics. Proceedings of the 5th Nordic Congress in Primary Health Care, Lund, 1985a.

Bassøe C-F: Five years of experience with a general, computer-based diagnostic system (combinatorics): Assessment of etiology. Proceedings of the 5th Nordic Congress in Primary Health Care. Lund; 1985b.

Bassøe C-F: Genetic diseases in general practice analyzed with an electronic patient record and combinatorics. Proceedings of the 5th Nordic Congress in Primary Health Care. Lund; 1985c.

Bassøe C-F: Myosis in general practice analyzed with an electronic patient record and combinatorics. Proceedings of the 5th Nordic Congress in Primary Health Care Lund; 1985d.

Bassøe C-F. A combinatorial diagnostic system for general practice. London: 11th Conference of the World Organisation of National Colleges, Academies and Academic Associations of General Practitioners/Family Physicians, 1986.

Bassøe C-F. A combinatorial diagnostic system for general practice: Evaluation of the social impact of disease by a computerized medical record. In: Hansen R, Solheim BG, O'Moore RR, Roger FH, editors. Lecture notes in medical informatics. Berlin: Springer-Verlag; 1988. p. 212-4.

Bassøe C-F. Natural language processing of medical records. Tidsskr Nor Legeforen. 1994;114:1974-6.

Bassøe C-F. Automated diagnoses from clinical narratives: A medical system based on computerized medical records, natural language processing and neural network technology. Neural Networks. 1995a;8:313-9. http://www.sciencedirect.com/science/article/pii/089360809400076X (Accessed 2018/10/16)

Bassøe C-F. The skinache syndrome. JRSM. 1995b;88:565-9. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1295357/ (Accessed 2018/8/16)

Bassøe C-F. Using narrative information stored in computerized physiotherapy records for physiotherapy research. 12th annual meeting I.B.I.T.A.H., Bergen, Norway, 1996.

Bassøe C-F. Combinatorial clinical decision-making. PhD dissertation, Department of Information Science and Media, Faculty of Social Sciences, University of Bergen, Norway, 2007a. ISBN 978-82-308-0457-5.

Bassøe C-F. A Data Structure For Decision Support Systems, Medical Expert Systems and Clinical Decision Making. In: MEDINFO 2007 Brisbane. Kuhn KA, Warren JR, Leong T-Y. (Eds.) Amsterdam: IOS Press; 2007b. p. 350.

Bassøe C-F. Representing Health, Disease and their Transitions by Digraphs. Stud Health Technol Inform. 2008;136:133-8.

Bassøe C-F. Biology and disease for health informaticians. The Norwegian EHR Research Centre (NSEP) at the Norwegian University of Science and Technology (NTNU), Trondheim: 2009. ca. 350 pages.

Bassøe C-F. A clinical model. I: Health. EkviMed Clinical Informatics. 2019.

Bassøe C-F. A clinical model. II: Disorder, etiology, pathogenesis. EkviMed Clinical Informatics. 2019a.

Bassøe C-F. A clinical model III: Universal diagnosis syntax. EkviMed Clinical Informatics. 2019b.

Bassøe C-F. A clinical model IV: The formal version. EkviMed Clinical Informatics. 2019c.

Bellamy JE. Medical diagnosis, diagnostic spaces, and fuzzy systems. J Am Vet Med Assoc. 1997;210:390-6.

Botsis T, Bassøe CF, Hartvigsen G. Sixteen years of ICPC use in Norwegian primary care: looking through the facts. BMC Med Inform Decis Mak. 2010;10:11. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2848129/ (Accessed 2018/8/16)

Casti JL. Reality rules: II. New York: John Wiley; 1997, p. 314-319.

Chowdhury B, Garai A, Garai G. An optimized approach for annotation of large eukaryotic genomic sequences using genetic algorithm. BMC Bioinformatics. 2017;18:460. https://bmcbioinformatics.biomedcentral.com/articles/10.1186/s12859-017-1874-7 (Accessed 2087/10/11)

Curé OC, Maurer H, Shah NH, Le Pendu P. A formal concept analysis and semantic query expansion cooperation to refine health outcomes of interest. BMC Med Inform Decis Mak. 2015;15 Suppl 1:S8. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4460622/ (Accessed 2017/1/17)

de Lusignan S. What is primary care informatics? J Am Med Inform Assoc. 2003;10:304-9.

Derbyshire J. Unknown quantity. Washington: Joseph Henry Press; 2006. p. 94.

Fredrickson DS. 'Venice' is not sinking (the water is rising). JAMA. 1982;247:3072-5.

Freeze WS. Expert guide to Visual Basic 6. San Francisco: Sybex; 1998.

Hammond N, Kløve T, Bassøe C-F. Knowledge structures for a general medical diagnostic system. In: Hansen R, Solheim BG, O'Moore RR, Roger FH, editors. Lecture notes in medical informatics. Berlin: Springer-Verlag; 1988;35:620-4.

Hesslow G. Do we need a concept of disease? Theoret Med. 1993;14:1-14. https://www.ncbi.nlm.nih.gov/pubmed/9057925 (2017/3/26)

ICD10. International Classification of Diseases (ICD) http://www.who.int/classifications/icd/en/ (Accessed 2015/12/1)

ICPC-2. International Classification of Primary Care (ICPC) http://www.who.int/classifications/icd/adaptations/icpc2/en/ (Accessed 2012015/12/01) ICPC-2. Norwegian version. http://www.kith.no/upload/1895/ICPC-2-bok_110304.pdf 2015 (Accessed 2015/12/01)

Maddox J. Complicated measures of complexity. Nature. 1990;344:705.

Newell A, Simon HA. Computer science as empirical inquiry: Symbols and Search. Commun ACM. 1976;19:113-26.

Rasmussen J-E, Bassøe C.-F. Semantic analysis of medical records. Meth Inform Med. 1993;32:66-72.

Rector A. Medical informatics. In. Baader F, Calvanese D, McGuinness DL, Patel-Schneider PF. The description logic handbook. Cambridge: Cambridge University press; 2007. p. 436-57.

Siler B, Spotts J. Using Visual Basic 6. Indianapolis: Que; 1998.

Spiegel MR. Vector Analysis. New York: McGraw-Hill; 1959.

Thomsen E. OLAP solutions. New York: Wiley; 2002.

Viereck J, Kumarswamy R, Foinquinos A, Xiao K, Avramopoulos P, KunzLong M, et al. noncoding RNA Chast promotes cardiac remodeling. Science Translational Medicine. 2016: 8;326:326ra22. DOI: 10.1126/scitranslmed.aaf1475 http://stm.sciencemag.org/content/8/326/326ra22.abstract?utm_campaign=email-stm-toc&et_rid=16740123&et_cid=282158 (Accessed 2016/2/23)

Wehkamp J, Salzman NH, Porter E, Nuding S, Weichenthal M, Petras RE, et al. Reduced Paneth cell alpha-defensins in ileal Crohn's disease. Proc Natl Acad Sci USA. 2005;102:18129-34.

Wolfram S. Cellular automata and complexity. Reading: Addison Wesley; 1994, p. 173-174, p. 491-497.

List of contents

Collapsing complexity

On-Line Analytical Processing (OLAP)

Conclusions

Methods

List of abbreviations

Author’s contribution

Acknowledgements

References