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Automated Diagnostic Systems

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Abstract:
Reaching a foolproof diagnosis is never an easy job for a clinician. Often, a simple diagnostic procedure or test is overlooked and the disease eludes diagnosis. Clinical reasoning and decision making are phased. Initially there is a clinical evaluation (history taking and physical examination), followed by precise laboratory investigations. Then integration of clinical findings and test results is done. After that, comparative benefits and risks are weighed among the alternative courses of actions, like drug interactions. Finally, the patient's preferences are taken into account, along with ethical and other considerations like cost of therapy, compliance expectations and a therapeutic plan is developed. Right from the first step (history taking) to the final one, computers can be of immense help to the clinician. CDSS (Clinical or Diagnostic Decision Support Systems) are Interactive computer programs, which directly assist physicians and other health professionals with decision making tasks. I have the pleasure of developing some diagnostic decision support systems for medical education and research. Intuitive thought processes involve rapid unconscious data processing and combines available information by law of average and therefore, has a low intra- and inter-person consistency. So, the clinician of today should move towards analytic decision making, which albeit typically slow, is conscious, consistent and clearly spells out the basis of decision. Nevertheless, for computer-assisted diagnostic systems, a human clinician ("man in the loop" for "Intelligence Amplification") must be a necessary component. Moreover, the clinician must understand completely the strengths and limitations of them. Computerized diagnostics and clinical acumen are not mutually exclusive; rather they should reinforce each other for the alleviation of psychosomatic or rather 'psycho-bio-social' suffering of mankind. However, with sophisticated gadgetry taking the upper hand, the "human touch" should not be overlooked or forgotten.
Keywords: automated clinical diagnosis, analytic decision making, CDSS

1. Introduction

Medical Informatics[1-7] is nothing but the science and art of processing (bio)medical information (where information is the processed data). The use of computers is inevitable here. The information may be retrieved both on-line (e.g., through Internet) or off-line (e.g., through CD-ROMS, floppies, magnetic tapes, and last but not the least: paper i.e., books and journals). EBM (Evidence Based Medicine) is gradually becoming popular for managing both common and uncommon medical problems. In this age of "Information Explosion" choosing the useful one is rather difficult, and that brings in the scope of data management and research. The usefulness of a database can be assessed only by its proper management (building, indexing and updating). However, still many outstanding personnel related to the healthcare sector take pride in being "computer illiterate".

The gamut encompassing Bioinformatics is a rather wide one. While referring to Bioinformatics, one thinks of only genomics, proteomics, and drug design, but the importance of ***clinical informatics*** is no less. Another term ***Tele-health*** encompasses both ***e-health*** (electronic or Internet based services related to healthcare delivery) and ***telemedicine*** (healthcare services to remote locations).

Reaching a foolproof diagnosis is never an easy job for a clinician. Often, a simple diagnostic procedure or test is overlooked and the disease eludes diagnosis. Clinical reasoning and decision making are phased. Initially there is a clinical evaluation, followed by precise laboratory

investigations. Then integration of clinical findings and test results is done. After that, comparative benefits and risks are weighed among the alternative courses of actions, like drug interactions. Finally, the patient's preferences are taken into account, along with ethical and other considerations like cost of therapy, compliance expectations and a therapeutic plan is developed. Right from the first step (history taking) to the final one, computers can be of immense help to the clinician. ***CDSS (Clinical or Diagnostic Decision Support Systems)*** [1,8-10] are Interactive computer programs, which directly assist physicians and other health professionals with decision making tasks. I have the pleasure of developing some CDSS. One such example is available in the Reference Website 6. Nevertheless, for computer-assisted diagnostic systems, a human clinician ("man in the loop" for "Intelligence Amplification) must be a necessary component. Moreover, the clinician must understand completely the strengths and limitations of them. Computerized diagnostics and clinical acumen are not mutually exclusive; rather they should reinforce each other for the alleviation of psychosomatic suffering of mankind. ***EBM (Evidence Based Medicine)*** is a conscientious, explicit and judicious use of current best evidence for making decisions about care of individual patient, in a scientific and systematic manner. Its scopes lie in (a) Decisions in clinical medicine, (b) Therapeutic evaluations, (c) Preventive strategies and screening, (d) Healthcare policies, (e) Health economics and (f) Research and innovations.

2. Modes of Information

The (clinical) information can be obtained through various modalities like ***voice*** (face to face or telephonic or video conversation of the patient, doctor or other healthcare personnel) or ***audio*** (breath or heart or peristaltic sounds, adventitious sounds).

The next mode of data transfer may be ***images*** (digitized X-rays, histopathological, hematological or microbiological slides, USG scan, CT scan, MRI scan) or scanned or plotted versions of EKG, EEG, EMG and other ***signals***. Alternatively, the signals may be transmitted as ASCII values and plotted at the receiving end; here the information loss will be minimal.

Another important modality is ***text*** data (e.g., blood, urine or csf report for biochemistry, pathology, microbiology or a specialist's comments).

All these have to be appropriately classified and linked adequately to the databases of a CBPR (Computer based patient record).

A ***combination*** of the above may be required most of the times for reaching a proper diagnosis, either in a remote setting or in the hospital itself where the data is collected. The transmission may be through PSTN (Public switched telephone network, also known as POTS or Plain old telephone system), ISDN (Integrated Services Digital Network), VSAT (very small aperture terminal) or newer modalities like T1, T2 or T3 leased lines (64 Kbps or kilobytes per second leased line uses standard telephone wire and is the least expensive type of connection, T1 connection can carry data at 1.544 Mbps, approximately 27 times the capacity of a 56K line, while a T3 connection is a costly high capacity trunk line, and is only usually used by large Internet Service Providers and corporations).

The modes of transmission may be either "store and forward" (slow connectivity is acceptable here) or "online" (at least 384 kbps bandwidth is essential for teleconsultation).

In an advanced situation, ***mechanical intervention*** (e.g., robotic telesurgery) may also be rendered through a tele-link.

3. CDSS

Clinical (or Diagnostic) Decision Support Systems (CDSS or DDSS) are interactive computer programs, which directly assist physicians and other health professionals with decision making tasks.

For medical diagnosis, there are scopes for ***ambiguities*** in inputs, like, (a) ***history*** (patient's description of the diseased condition - a relative degree of threshold for suffering, or quality of expression of complaints), (b) ***physical examinations*** (especially in cases of uncooperative or less intelligent patients), and also in the (c) ***laboratory tests*** (faulty methods or equipment). Moreover, for ***treatment***, there are chances of: (a) drug reactions and specific allergies, and (b)

patients non-compliance of the therapy due to cost or time or adverse reactions. All these have to be encoded properly to form a working CDSS.

The basic components of a CDSS are: (a) knowledge base and (b) inference mechanism. The advantages are that they are prompt, logical, definitive, prone to less chance of errors, purvey stepwise checklists, unnecessary expensive tests may be avoidable, and remote networking is also possible. The inherent limitations to any CDSS are that (a) final solution may be unknown and also, (b) "man in the loop" essential.

For building a Knowledge Base and utilizing it for Decision making, the early models were: (a) logical / deductive: branching logic (e.g., ID3 or iterative dichotomizer 3); e.g., MYCIN, (b) probabilistic: Bayesian e.g., de Dombal and (c) hybrid: heuristic reasoning e.g., QMR, DXplain, ILIAD.

Presently the active assistant or clinical event monitor e.g., HELP, CPMC models are preferred. Integrated CDSS combines CBR (case based reasoning), ANN (artificial neural networks), Bayesian, Procedural, and Production Rule methods in various proportions[8-10], in accordance with the need.

Health Level 7 (HL7) standard recommends for Clinical Decision Support (Rules-based, automated clinical decision support), MLMs (Medical Logic Modules having Maintenance, Library and Knowledge elements in Arden MLM XML schema of HL7), Protocols, Guidelines, Clinical Trials. Here, the Messages include - alerts, precondition master file messages, guideline compliance, guideline variance tracking.

Now, let us elaborate on a term "Expert System".

Expert Systems (ES) are complex AI (artificial intelligence) programs. The most widely used way of representing domain knowledge in ES is as a set of production rules, which are often coupled with a frame system that defines the objects that occurs in the rules.

Connectionist ES are ANN based ES where the ANN generates inferencing rules e.g., fuzzy-MLP where linguistic and natural form of inputs are used. Apart from that, rough set theory may be used for encoding knowledge in the weights better and also GAs (genetic algorithms) may be used to optimize the search solutions better and faster.

4. Conclusions

Because of advent of new modalities of treatment, almost daily, decision making towards a particular treatment regime to be adopted for each individual patient becomes a complex process. More often, a large amount of information has to be processed, much of which is quantifiable. Intuitive thought processes involve rapid unconscious data processing and combines available information by law of average and therefore, has a low intra- and inter-person consistency. So, the clinician of today should move towards analytic decision making, which albeit typically slow, is conscious, consistent and clearly spells out the basis of decision. Interested and uninitiated readers are encouraged to visit the Reference websites 6 and 7 for having a first hand exposure of a CDSS.

Computerized diagnostics and clinical acumen are not mutually exclusive; rather they should reinforce each other for the alleviation of psychosomatic suffering of mankind. However, with sophisticated gadgetry taking the upper hand, the "human touch" should not be overlooked or forgotten.

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Some useful websites:

1. http://www.isabel.org/
2. http://www.medal.org/
3. http://www.mentor-update.com/
4. http://www.openclinical.org/
5. http://www.prodigy.nhs.uk/ (Prescribing RatiOnally with Decision-support In General-practice studY)
6. www.geocities.com/drsupten (contains a CDSS on amenorrhea developed by the author)
7. www.emedicine.com/splash/shared/etools (interactive site for skin rashes' diagnosis)
8. www.hl7.de/downloads/iajm2000/jenders.pdf
9. http://www.amia.org/
10. http://www.hl7.org/ (HL7)