

USE OF SELF-LEARNING ALGORITHMS IN MEDICAL EDUCATION

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Abstract

Researchers have examined methods of using self-learning algorithms in the process of lifelong education, e.g. through distance or factual eLearning forms, or as a means of educating health care professionals from various perspectives. In other words, using it for the provision of the respective health care, for biomedical research, and for the electronic delivery of e-learning. In addition, the authors discuss how self-learning algorithms can make electronic educational data more effective and how they can ensure the spread of functional health care information systems.

Keywords: *self-learning algorithms, education, healthcare professionals, eHealth*

1. INTRODUCTION

The development of eHealth in the current computerized society is supported with the aim to create large network of health information systems that would be able to ensure communication between health care providers and the storage of healthcare data, including health documentation in electronic form (Ellaway et al. 2013). These systems are basically just based on database and information security algorithms. Minimal attention is paid to the possibilities of using more sophisticated algorithms such as self-learning algorithms. Self-learning systems can therefore be defined as systems with “the ability of all living systems to organize themselves into patterns and structures without any externally imposed plan or directions”. In a self-learning system, change is not only inevitable but is a powerful, creative force resulting from earlier stages of system instability. Instability is sometimes desirable, even necessary. Purposeful (but subtle) perturbations can, if appropriately encouraged and balanced, lead to a desirable order for the system. If a system has always been stable, no change is ever warranted and no new learning can be achieved. For example, if the traditional health care systems were sufficient and there had been no technological advances, economic pressures, or breakthroughs in system thinking, health care would never have evolved into the e-health era. Left alone, self-learning systems would improve over time on their own because they are preprogrammed to learn and adapt to changing environments (Tan 1995).

Self-learning algorithms can be used for electronic healthcare in two ways: either to improve existing health information systems or as a tool to increase the efficiency of the educational process. Implementation of self-learning algorithms in various types of health information systems, especially in local hospital and outpatient systems would allow to extend their functionality from simple medical records to more complex processes, e.g. to accelerate and refine diagnostics and medical research. The prerequisite for the correct use of these algorithms is the necessity to become familiar with them in pre- and post-graduate education for healthcare professionals.

eLearning can be also considered as one of the segments of eHealth when applied to the education of healthcare professionals, not only for the professional performance, but also for increasing their competence (Stovel et al. 2020; Frank et al. 2010). eHealth and eLearning partially overlapping in this area, similarly as in other area eHealth and eGovernment. eLearning is one of the forms and means of distance learning. It is implemented through the communication capabilities of information technology and through the eLearning algorithms. Enrich eLearning with a self-learning algorithm would support the personalization of education, thereby increasing its efficiency and effectiveness (Harden et al. 2020).

2. SELF-LEARNING ALGORITHMS

Self-learning algorithms (SLA) are algorithms that are able to ensure adaptation of the database system where they are implemented through patterns. A typical task of a self-learning algorithm is classification. The internal parameters of the classifier system are based on the set of input data and their correct classification into classes (which must be prepared by an expert – teacher) so when submitting new data, they classify them with sufficient accuracy (with a non-statistically significant error). In other words, the self-learning system adjusts its internal environment (it learns) to gradually optimize its responses to the desired outputs (Figure 1).

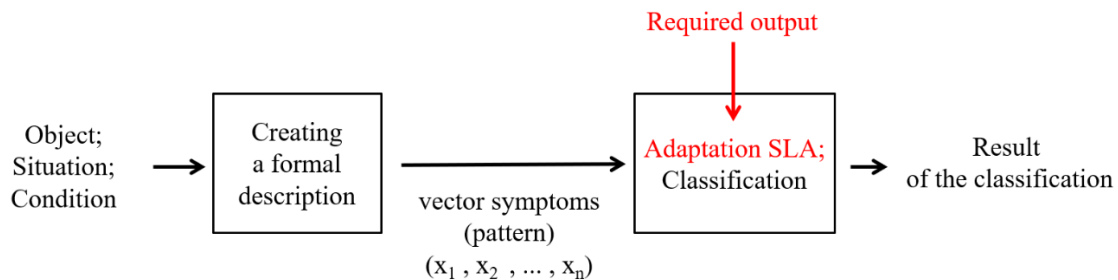


Fig. 1. The learning processes

Self-learning algorithms include a large class of algorithms that can be divided into three groups from a mathematical-information point of view based on:

- statistical methods (pattern recognition schemes),
- inductively creating decision trees (Dietterich 2003),
- neural network models.

Regardless of the mathematical form, the self-learning algorithms have a common essential feature from a user's perspective. It is the ability to induce, generalize information and internally generate rules based on the so-called training set of patterns, respectively gradually specify these rules. The rules can be used to classify, evaluate new patterns that have not yet occurred. All self-learning algorithms face the problem of finding a balance between three factors: the complexity of the obtained classifier, the volume of training data and the accuracy of new data classification. In particular, the classification accuracy usually increases with the larger volume of training data. As the complexity of the classifier increases the classification accuracy – first increases and then decreases. Basically, the more training data available, a higher classification level can be achieved.

2.1. Self-learning algorithms in medicine

From the beginning, the self-learning algorithms were designed, tested and used in a limited extent in individual medical disciplines (Kaul et al. 2020). Diagnostics is a typical problem for self-learning algorithms application. However, these algorithms can be applied in several other medical areas (Joda et al. 2019). The ability of these algorithms to generalize individual data and to generate more general rules according to them, determines the scope of use in general knowledge, especially in medicine (O'Byrne et al. 2008). From the application point of view, the areas of use can be divided into the following four groups:

- diagnostic support,
- biomedical research,
- adjustment of diagnostic and therapeutic devices and devices according to the patient characteristic parameters,
- personalization of electronic knowledge sources for healthcare professionals.

2.1.1. Diagnostic support

As was mentioned above, the most common problem in diagnostics can be solved by using self-learning algorithms. These systems cannot work independently, work only as a support tools. They provide the physicians and other healthcare professionals with additional secondary information needed for rapid and accurate diagnostics, particular in the diagnostics of specific and infrequent diagnoses.

The results of examinations and data on established diagnosis are available in the form of medical documentation in hospitals and outpatient clinics. At present, this data is continuously entered into local hospital information systems. They are available in electronic form. All we need to do for using self-learning algorithms, is to prepare and justify them. We present the comparison process in a simple way, because we basically assumed that medical diagnostic knowledge can be derived from cases solved in the past. The classifier setting can be based on the stored data. This classifier can be used by the physician to support decision-making in diagnosing a new patient with respect to increasing diagnostic speed, accuracy and reliability.

2.1.2. Biomedical research

Current self-learning algorithms provide several irreplaceable tools for intelligent data analysis. Especially in recent years, the digital revolution has provided relatively affordable and marketable means of collecting and storing data. Modern hospitals are now well equipped with monitoring and other devices that record medical data in hospital information systems (HIS). Self-learning algorithms are currently very suitable for these analyses. Although there is already a rich experience with the use of these algorithms, they are not yet sufficiently used to gain new medical knowledge in practice.

2.1.3. Adjustment of diagnostic and therapeutic devices and devices according to the patient characteristic parameters

Optimal examination results, respectively therapy management in the choice of supportive medical examination methods using devices equipped with PC (X-ray, CT, NMR and other imaging methods) depend on the correct setting of parameters that characterize a patient, e.g. anthropometry (Heinzel et al. 2020). In this case, a self-learning algorithm can be advantageously used, since it can remember these parameters and may assign them to individual patients, this would not only speed the examination process but also increase the reliability of the examination.

2.1.4. Personalization of electronic knowledge sources for healthcare professionals

Currently, much of the medical knowledge is available electronically via the Internet. Every healthcare professional - specialist needs to have quick access to sources of knowledge that are relevant to his/her specialization and to a range of related disciplines (Button et al. 2014). A self-learning algorithm can ensure that in the background of his/her a daily routine, a set of Internet links that meets his/her specific needs will be created and updated.

3. CONCLUSIONS

3.1. Personalization of electronic knowledge sources for healthcare professionals

The term eLearning refers to the distance learning, which is carried out by means of communication and information technologies within their current possibilities (Kostolányová 2014). The knowledge is processed in the form of multimedia teaching programs, which combine text, images and sound. e-Learning uses training programs, case studies as simulations of real situations, animated tutorials, various types of tasks, exercises, tests in electronic form (Ruiz et al. 2006). Teaching programs can be distributed on CD-ROM, via computer networks (Internet), respectively combined way (Sezer 2016).

Basic characteristics of eLearning:

- Educational process using the electronic learning materials, multimedia technologies and electronic media (Diab et al. 2009).

- Individual electronic lessons (e-course) are presented to the student, the content of the course is being transmitted in the Internet, intranet, interactive television programs, educational CD-ROMs, etc.
- The e-course consists of thematically comprehensive lessons. Each lesson is usually completed with a test. If the student has passed the test, he/she can continue with the next lesson.
- The e-course contains only the most significant information, the additional is presented with hyperlinks.
- The teacher can check the knowledge of the students by suitable tests.
- Support to study is provided by the so-called Learning management system.

The educational objective of eLearning is self-study, the student studies from electronic materials (Choules 2007). He / she can test himself / herself how he understood the material and, if necessary, return to the study materials, he / she did not understand (Mohanna 2007). Finally, his / her knowledge is tested by a control test. This general procedure can also be performed as a learning algorithm for eLearning.

It is also possible to use a self-learning algorithm in eLearning. The concept of enriching the eLearning with self-learning algorithm is based on the idea that even in eLearning, the student should be approached individually.

Therefore, it is necessary to implement a self-learning algorithm into the education management system with the option to induce a personal characteristic of the student's knowledge based on access to the available study materials (also on continuity, speed communication and the related successful test results).

Based on these personal characteristics, it would be possible to modify the study material, e. g. increase the number of examples on a topic that cause problems for the student or examination of a particular topic in more detail way. Enriching eLearning with a self-learning algorithm will enable personalized learning, thereby increasing its efficiency.

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REFERENCES

1. Button D, Harrington A, Belan I. 2014. "E-learning & information communication technology (ICT) in nursing education: A review of the literature", *Nurse Education Today*, vol 34(10):1311-23.
2. Diab A, Wuttke H. 2009. "Personalisation of e-Learning content via metadata", *Proceedings of the 12th IASTED International Conference on Computers and Advanced Technology in Education*, CATE 20092009:102-106.
3. Dietterich, TG. 2003. *Machine Learning*. Nature Encyclopedia of Cognitive Science, London: Macmillan, viewed 6 October 2021, <<http://web.engr.oregonstate.edu/~tgd/publications/nature-ecs-machine-learning.pdf>>.
4. Ellaway RH, Graves L, Greene PS. 2013. "Medical education in an electronic health record-mediated world", *Medical Teacher*, vol. 35(4):282-6.
5. Frank JR, Mungroo R, Ahmad Y, Wang M, De Rossi S, Horsley T. 2010. "Toward a definition of competency-based education in medicine: A systematic review of published definitions", *Medical Teacher*, vol. 32(8):631-7.

6. Harden RM, Laidlaw JM. 2020. "Essential Skills for a Medical Teacher: An Introduction to Teaching and Learning in Medicine" Edinburgh: Churchill Livingstone Elsevier.
7. Heinzel A, Marienhagen J, Yekta-Michael SS, Mottaghy FM, Krzemien J, Lemos M. 2020. "Pilot study of a newly developed eLearning tool to teach CT and PET/CT in radiology and nuclear medicine", *Nuklearmedizin*, vol. 59(2):79-84.
8. Choules AP. 2007. "The use of elearning in medical education: a review of the current situation", *Postgraduate Medical Journal*, vol. 83(978):212-6.
9. Joda T, Waltimo T, Probst-Hensch N, Pauli-Magnus C, Zitzmann NU. 2019. "Health data in dentistry: An attempt to master the digital challenge", *Public Health Genomics*, vol. 22(1-2):1-7.
10. Kaul V, Enslin S, Gross SA. 2020. "History of artificial intelligence in medicine", *Gastrointestinal Endoscopy*, vol. 92(4):807-12.
11. Kostolányová K, Šarmanová J. 2014. "Use of adaptive study material in education in E-learning environment", *Electron Journal of e-Learning*, vol. 12(2):172-82.
12. Kralova E. 2017. "Motivation of medical students to study physical, chemical and biological sciences – survey results", *EDULEARN 17. Proceedings*, 1: 9220-9223.
13. Mohanna K. 2007. "The use of elearning in medical education", *Postgraduate Medical Journal*, vol. 83(978):211.
14. O'Byrne PJ, Patry A, Carnegie JA. 2008. "The development of interactive online learning tools for the study of anatomy", *Medical Teacher*, vol. 30(8):e260-71.
15. Ruiz JG, Mintzer MJ, Leipzig RM. 2006. "The Impact of E-Learning in Medical Education", *Academic Medicine*, vol. 81(3):207-212.
16. Sezer B. 2016. "Faculty of medicine students' attitudes towards electronic learning and their opinion for an example of distance learning application", *Computer Human Behavior*, vol. 55:932-9.
17. Stovel RG, Gabarin N, Cavalcanti RB, Abrams H. 2020. "Curricular needs for training telemedicine physicians: A scoping review", *Medical Teacher*, vol. 42(11):1234-1242.
18. Tan J, editor. 2005. "E-Health Care Information Systems: An Introduction for Students and Professionals", San Francisco (CA): Jossey-Bass A Wiley Imprint.
19. Trnka M, Kráľová E. 2020. "News in didactic technologies used in the teaching of medical biophysics in the conditions of COVID-19 pandemic", *ICERI2020 Proceedings*, 1:6806.