applied sciences

MDPI

Editorial

Research Directions of Applied Cognitive Sciences

Attila Kovari

Department of Computer Science, GAMF Faculty of Engineering and Computer Science, John von Neumann University, 6000 Kecskemét, Hungary; kovari.attila@o365.uni-neumann.hu

1. Introduction

Cognitive science is an interdisciplinary field of investigation of the mind and intelligence. The term cognition refers to different mental processes, including perception, problem solving, learning, decision-making, language use, and emotional state and experience [1]. The contributions of philosophy and computer science to the investigation of cognition are the basis of cognitive sciences. Computer science is very important in the investigation of cognition, because computer-aided research, machine learning [2] and decision-making [3] methods help to develop the mental processes, and computers are useful in testing scientific hypotheses about mental organization and functioning. In addition, the emergence of human-computer interfaces, such as eye movement tracking, allows the observation and examination of cognitive load in relation to a more complex cognitive process. [4,5] Empirical theories are very important for guiding practice (including education, pedagogy, or psychology) and operational research and engineering, and in particular, the design of human-computer interfaces that can be used efficiently without placing too much emphasis on human intellectual abilities. Studies using psychological experiments and computational models are also very important in mental health diagnosis and treatment. Cognitive science plays a significant role in the field of mental illnesses, such as depression, and neurodevelopmental disorders. More specifically the understanding of the possible mechanisms that underlie them and the way interventions work require an understanding of how the mind works. This special issue provides a platform for a review of these disciplines and the presentation of cognitive research as an independent field of study.

The main focus of this special issue includes the next topics:

1. cognition;
2. user experiences; user satisfaction;
3. human–AI interaction; interaction design;
4. human–robot interaction;
5. emotional interfaces;
6. voice-based intelligent system;
7. dynamic gesture recognition; gesture spotting;
8. internet addiction;
9. dysfunctional emotions; emotional problems; stress;
10. computational psychology; computational cognitive modeling; computational creativity;
11. privacy-preserving computations; homomorphic encryption;
12. problem solving and decision making;
13. learning and assessment; computer adaptive testing;
14. code tracing; basic programming skills;
15. functional vision; vision screening; vision training;
16. eye-tracking; eye–brain–computer interfaces;
17. machine learning; deep learning;
18. clustering; spatially prolonged risk;
19. instance selection; clustering; information processing

check for updates

Citation: Kovari, A. Research Directions of Applied Cognitive Sciences. *Appl. Sci.* **2022**, *12*, 5789. https://doi.org/10.3390/app12125789

Received: 6 June 2022
Accepted: 6 June 2022
Published: 7 June 2022

20. virtual reality; virtual environment; virtual simulation;
21. internet of things; heart rate.

2. Overview of Research Directions Based on the Spec Issue Papers

The main content and results of the articles published in the spec issue are summarized below.

Cecilia Hammar Wijkmark et al. [6] presents the necessary enablers for setting up Remote Virtual Simulation (RVS) and its influence on cognitive aspects of assessing practical competences. Data were gathered through observations, questionnaires, and interviews from students and instructors, using action-case research methodology. The results show the potential of RVS for supporting higher cognitive processes, such as recognition, comprehension, problem solving, decision making, and allowed students to demonstrate whether they had achieved the required learning objectives. Other reported benefits were the value of not gathering people (imposed by the pandemic), experiencing new, challenging incident scenarios, increased motivation for applying RVS based training both for students and instructors, and reduced traveling.

Qasim Ali et al. [7] showing a rapid review to a better understanding of the importance of vision screening for school-aged children, and to investigate the possibilities of how eye-tracking (ET) technologies can support this. The authors review interdisciplinary research on performing vision investigations and discuss current challenges for technology support. The focus of the paper is on exploring the possibilities of ET technologies to better support screening and handling of vision disorders, especially by non-vision experts. The data originate from a literature survey of peer-reviewed journals and conference articles complemented by secondary sources, following a rapid review methodology. The authors highlight current trends in supportive technologies for vision screening and identify the involved stakeholders and the research studies that discuss how to develop more supportive ET technologies for vision screening and training by non-experts.

Robert Pinter et al. [8] analyzes the application of Computer adaptive testing (CAT) which enables an individualization of tests and give better accuracy of knowledge level determination [9]. The authors compare the results of questions' difficulty determination given by experts (teachers) and students. Analyzing the correct answers shows that the basic programming knowledge, taught in the first year of study, evolves very slowly among senior students. The comparison of estimations on questions difficulty highlights that the senior students have a better understanding of basic programming tasks; thus, their estimation of difficulty approximates to that given by the experts.

Jan Francisti et al. [10] describes the possibilities of using commonly available devices such as smart wristbands (watches) and eye tracking technology, i.e., using existing technical solutions and methods that rely on the application of sensors while maintaining non-invasiveness. By comparing the data from these devices, the authors observed how the students' attention affects their results. The results show a correlation between eye tracking, heart rate, and student attention and how it all impacts their learning outcomes.

Cristina Costescu et al. [11] investigate the relationship between coping mechanisms, dysfunctional negative emotions, and Internet use. The authors measured participants' coping strategies, emotional distress, social and emotional loneliness, and their online behavior and Internet addiction using self-report questionnaires. The results showed that maladaptive coping strategies and Internet use were significant predictors of dysfunctional negative emotions. Moreover, passive wishful thinking, as a pattern of thinking, was associated with anxious and depressed feelings. The relation between Internet use and dysfunctional negative emotions was mediated by participants' coping mechanisms. The authors conclude that the level of negative feelings is associated with the coping strategies used while showing an increased level of Internet addiction.

Jong-Gyu Shin et al. [12] proposed a method to evaluate user satisfaction during interaction between a voice-based intelligent systems (VIS) and a user-centered intelligent system. As a user satisfaction evaluation method, a VIS comprising four types of design

parameters was developed and user satisfaction was measured using Kansei words (KWs). The questionnaire scores collected through KWs were analyzed using exploratory factor analysis and ANOVA was used to analyze differences in emotion. On the "pleasurability" and "reliability" axes, it was confirmed that among the four design parameters, "sentence structure of the answer" and "number of trials to acquire the right answer for a question" affect the emotional satisfaction of users.

Hiroomi Hikawa et al. [13] proposed a real-time dynamic hand gesture recognition system with gesture spotting function. In the proposed system, input video frames are converted to feature vectors, and they are used to form a posture sequence vector that represents the input gesture. The introduced gesture recognition method was tested by simulation and real-time gesture recognition experiment. Results shows that the system could recognize nine types of gesture with an accuracy of 96.6%, and it successfully outputted the recognition result at the end of gesture using the spotting result.

Rahul Sharma et al. [14] used the Toy-data problem in their paper to illustrate the regulated activation network modeling and recall procedure to report the computational simulation of the cued recall of abstract concepts by exploiting their learned associations. The results show how regulation enables contextual awareness among abstract nodes during the recall process. The authors show that every recall process converges to an optimal image. With more cues, better images are recalled, and every intermediate image obtained during the recall iterations corresponds to the varying cognitive states of the recognition procedure.

María Consuelo Sáiz-Manzanares et al. [15] analyze the results obtained with the eye tracking methodology by applying statistical tests and supervised and unsupervised machine learning techniques, and to contrast the effectiveness of each one. The parameters of fixations, saccades, blinks and scan path, and the results in a puzzle task were found. The statistical study concluded that no significant differences were found between participants in solving the crossword puzzle task; significant differences were only detected in the parameters saccade amplitude minimum and saccade velocity minimum. On the other hand, this study, with supervised machine learning techniques, provided possible features for analysis, some of them different from those used in the statistical study. Regarding the clustering techniques, a good fit was found between the algorithms used (k-means ++, fuzzy k-means and DBSCAN).

Andrea Bianca Popescu et al. [16] propose an encoding method that enables typical homomorphic encryption schemes to operate on real-valued numbers of arbitrary precision and size. The approach is evaluated on two real-world scenarios relying on EEG signals: seizure detection and prediction of predisposition to alcoholism. The results show that the prediction performance of the models operating on encoded and encrypted data is comparable to that of standard models operating on plaintext data.

Boris M. Velichkovsky et al. [17] implemented different modes of social gaze behavior in a companion robot, F-2, to evaluate the impression of the gaze behaviors on humans in three communicative situations. The authors extended the computer model of the robot in order to simulate realistic gaze behavior in the robot and create the impression of the robot changing its internal cognitive states. They used an iterative approach, extending the applied cognitive architecture in order to simulate the balance between different behavioral reactions and to test it in the experiments.

Žolt Namestovski and Attila Kovari [18] examine the process of creating successful, engaging, interactive, and activity-based online educational materials, while taking the cognitive aspects of learners into account [19]. The quality of online educational materials has become increasingly important in the recent period, and it is crucial that content is created that allows our students to learn effectively and enjoyably. The authors present the milestones of curriculum creation and the resulting model, the criteria of selecting online learning environments and also introduce some principles of instructional design, as well as a self-developed model that can be used to create effective online learning materials and online courses.

Tor Finseth et al. [20] investigate and validate different virtual reality (VR) stressor levels from existing emergency spaceflight procedures. Experts in spaceflight procedures and the human stress response helped design a VR spaceflight environment and emergency fire task procedure. Since stress is a complex construct, physiological data (heart rate, heart rate variability, blood pressure, electrodermal activity) and self-assessment (workload, stress, anxiety) were collected for each stressor level. The results suggest that the environmental-based stressors can induce significantly different, distinguishable levels of stress in individuals.

Adrian Rodriguez Aguiñaga et al. [21] presents the proposal of a method to recognize emotional states through EEG analysis. The novelty of this work lies in its feature improvement strategy, based on multiclass genetic programming with multidimensional populations (M3GP), which builds features by implementing an evolutionary technique that selects, combines, deletes, and constructs the most suitable features to ease the classification process of the learning method. After implementing the M3GP, the results showed an increment of 14.76% in the recognition rate without changing any settings in the learning method. The proposed methodology achieves a mean classification rate of 92.1%, and simplifies the feature management process by increasing the separability of the spectral features.

Milan Gnjatović et al. [22] introduces and illustrates an approach to automatically detecting and selecting "critical" road segments, intended for application in circumstances of limited human or technical resources for traffic monitoring and management [23]. The presented approach is psychologically inspired to the extent that it introduces a clustering criterion based on the Gestalt principle of proximity.

3. Conclusions

This short review of the papers shows that the Research Directions of Applied Cognitive Sciences offer a very wide range of research opportunities, which multidisciplinary will remain an important field of research for the future.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Magdin, M.; Balogh, Z.; Reichel, J.; Francisti, J.; Koprda, Š.; Molnar, G. Automatic detection and classification of emotional states in virtual reality and standard environments (LCD): Comparing valence and arousal of induced emotions. *Virtual Real.* **2021**, *25*, 1029–1041. [CrossRef]
2. Muhi, K.; Johanyak, Z.C. Dimensionality reduction methods used in Machine Learning. *Műsz. Tud. Közl.* **2020**, *13*, 148–151. [CrossRef]
3. Koncz, A.; Johanyak Zs, C.; Pokoradi, L. Multiple criteria decision-making method solutions based on failure mode and effect analysis. *Ann. Fac. Eng. Hunedoara-Int. J. Eng.* **2021**, *19*, 6.
4. Katona, J. Measuring Cognition Load Using Eye-Tracking Parameters Based on Algorithm Description Tools. *Sensors* **2022**, *22*, 912. [CrossRef] [PubMed]
5. Katona, J. Clean and Dirty Code Comprehension by Eye-tracking Based Evaluation using GP3 Eye Tracker. *Acta Polytech. Hung.* **2021**, *18*, 79–99. [CrossRef]
6. Wijkmark, C.H.; Metallinou, M.M.; Heldal, I. Remote Virtual Simulation for Incident Commanders—Cognitive Aspects. *Appl. Sci.* **2021**, *11*, 6434. [CrossRef]
7. Ali, Q.; Heldal, I.; Helgesen, C.G.; Krumina, G.; Costescu, C.; Kovari, A.; Katona, J.; Thill, S. Current Challenges Supporting School-Aged Children with Vision Problems: A Rapid Review. *Appl. Sci.* **2021**, *11*, 9673. [CrossRef]
8. Pinter, R.; Maravić Čisar, S.; Kovari, A.; Major, L.; Čisar, P.; Katona, J. Case Study: Students' Code-Tracing Skills and Calibration of Questions for Computer Adaptive Tests. *Appl. Sci.* **2020**, *10*, 7044. [CrossRef]
9. Szucs, R.S. Cognitive level of consumers' knowledge in the case of a few food products. *Eur. Sci. J.* **2014**, *10*, 58–65.
10. Francisti, J.; Balogh, Z.; Reichel, J.; Magdin, M.; Koprda, Š.; Molnár, G. Application Experiences Using IoT Devices in Education. *Appl. Sci.* **2020**, *10*, 7286. [CrossRef]
11. Costescu, C.; Chelba, I.; Roșan, A.; Kovari, A.; Katona, J. Cognitive Patterns and Coping Mechanisms in the Context of Internet Use. *Appl. Sci.* **2021**, *11*, 1302. [CrossRef]
12. Shin, J.-G.; Choi, G.-Y.; Hwang, H.-J.; Kim, S.-H. Evaluation of Emotional Satisfaction Using Questionnaires in Voice-Based Human–AI Interaction. *Appl. Sci.* **2021**, *11*, 1920. [CrossRef]

13. Hikawa, H.; Ichikawa, Y.; Ito, H.; Maeda, Y. Dynamic Gesture Recognition System with Gesture Spotting Based on Self-Organizing Maps. *Appl. Sci.* **2021**, *11*, 1933. [CrossRef]
14. Sharma, R.; Ribeiro, B.; Pinto, A.M.; Cardoso, A. Emulating Cued Recall of Abstract Concepts via Regulated Activation Networks. *Appl. Sci.* **2021**, *11*, 2134. [CrossRef]
15. Sáiz-Manzanares, M.C.; Pérez, I.R.; Rodríguez, A.A.; Arribas, S.R.; Almeida, L.; Martin, C.F. Analysis of the Learning Process through Eye Tracking Technology and Feature Selection Techniques. *Appl. Sci.* **2021**, *11*, 6157. [CrossRef]
16. Popescu, A.B.; Taca, I.A.; Nita, C.I.; Vizitiu, A.; Demeter, R.; Suciu, C.; Itu, L.M. Privacy Preserving Classification of EEG Data Using Machine Learning and Homomorphic Encryption. *Appl. Sci.* **2021**, *11*, 7360. [CrossRef]
17. Velichkovsky, B.M.; Kotov, A.; Arinkin, N.; Zaidelman, L.; Zinina, A.; Kivva, K. From Social Gaze to Indirect Speech Constructions: How to Induce the Impression That Your Companion Robot Is a Conscious Creature. *Appl. Sci.* **2021**, *11*, 10255. [CrossRef]
18. Namestovski, Ž.; Kovari, A. Framework for Preparation of Engaging Online Educational Materials—A Cognitive Approach. *Appl. Sci.* **2022**, *12*, 1745. [CrossRef]
19. Hardi, J. An overview of metacognitive strategies in young learners' vocabulary learning. *GRADUS* **2015**, *2*, 46–60.
20. Finseth, T.; Dorneich, M.C.; Keren, N.; Franke, W.D.; Vardeman, S.B. Manipulating Stress Responses during Spaceflight Training with Virtual Stressors. *Appl. Sci.* **2022**, *12*, 2289. [CrossRef]
21. Rodriguez Aguiñaga, A.; Muñoz Delgado, L.; López-López, V.R.; Calvillo Téllez, A. EEG-Based Emotion Recognition Using Deep Learning and M3GP. *Appl. Sci.* **2022**, *12*, 2527. [CrossRef]
22. Gnjatović, M.; Košanin, I.; Maček, N.; Joksimović, D. Clustering of Road Traffic Accidents as a Gestalt Problem. *Appl. Sci.* **2022**, *12*, 4543. [CrossRef]
23. Boldizsar, A. Statistical analysis of road freight transport in Catalonia. *Prod. Eng. Arch.* **2022**, *28*, 40–49. [CrossRef]