Ambient Intelligence and e-Learning

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A General Survay

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Abstract: The use of ambient intelligence knowledge inevitably leads to a new education concept particularly in creating an environment towards the implementation of teaching as well as the process of education. The process of teaching and education, besides conventional and physical elements of the environment, will be enriched with elements regarding modern information technology.

Ambient intelligence will be presented in this paper as a result of the artificial algorithm neural networks, through the following contexts: e-learning environment, identification, and security.

The key role in raising students' achievements as well as competency levels belongs to modern information technology which works towards creating ambient intelligence. It is also executed through the concept of e-learning onto one of the convenient learning management platforms.

Survey results indicate that with the use of ambient intelligence, better results are achieved, especially in mathematics taught at the elementary school level. Furthermore, learned lessons are memorized by students for a long period, which is proved by higher levels of students' knowledge and skill acquisition in terms of general progress.

Keywords: ambient intelligence, e-learning, neural networks.

Introduction

The subject of the research represents analyses of how ambient factors influence the success of students who use e-learning platforms in the teaching process.

Ambient intelligence should provide students with optimal conditions for monitoring classes. It should also allow teachers to keep track of how long and successfully involved students are in a particular activity. Recommendations towards enhancing activities can be electronically transmitted to convenient platforms or even to students' wristwatches [1].

The significance of ambient intelligence has been recognized as well as time applied by leading world-class companies such as Siemens, which has invested heavily in smart development buildings and autonomies in the production process in factory halls [2]. Nokia company has also invested significant resources in communication development which do not necessarily relate to smart homes only but have a much wider application for reasons of developed mobile applications [3].

Ambient intelligence [4, 5] is being developed within multidisciplinary fields thus allowing the benefit of research to be used for a variety of purposes. This paper deals with ambient intelligence in the function of enhancing e-learning.

The basic idea behind the concept of ambient intelligence is the adaptation of the environment with the help of information and communication technology for e-learning towards students' needs to achieve better results as well as greater achievement.

E-learning system should be built so that it adjusts teaching content to students' needs based on information in real-time.

Contemporary teaching, especially electronically shaped educational learning processes, and teaching, is getting closer and closer to the concept of stu-

dents' creation within the pedagogical framework activities. This increasingly signifies that the concept of constructionism is expanding. Regardless of the importance of constructing, rather than imposing knowledge, elements are still needed likewise instructive and constructivist approach in all teaching situations-from the traditional classroom-to-classroom teaching system, to the virtual classroom as well as e-learning [6,7,8,9].

Learning with modern strategies that use the concept of e-learning in comparison with traditional teaching is characterized by completely different relationships between students and teachers likewise modified forms of the process of teaching organization [10].

A student qualified for self-education represents one of the key goals in the process of education. Those methods of work that contribute to a more active attitude of students towards teaching content, should be given preference. Training students to use different sources of knowledge as well as becoming independent in the learning process is also very significant [11].

Previous research has not completely provided comprehensive answers to questions regarding the impact of the environment on e-learning, identification, and students' security within e-space. To properly perceive the impact of the environment on e-learning likewise the predictions of students' success at work, an analysis of the factors relevant to the success of the teaching process using neural network algorithms have been performed.

METHOD

While exploring the impact of ambient intelligence on the e-learning process, this paper has defined the largest factor, most relevant to students' achievements in the context of an e-learning environment, with the use of analytical hierarchical methods.

Analyses of the e-learning environment

Defined factors are further processed as input variables within an artificial neural network. Results obtained have been used to develop ambient intelligence in the e-learning enhancement function. In order to define the factors of greatest importance towards students' achievements, the authors of this paper have used extended AHP fusion method of triangular numbers that are performed in four steps [12] as follows:

Let X = {X_1X_1, X_2X_2, X_3X_3, ..., X_nX_n} be a set of objects, and G = {G_1G_1, G_2G_2, G_3G_3 ....., G_mG_m} be set of goals.

Each object is analyzed for each objective, respectively. Accordingly, *m* values for each object can be expressed as follows:

$M_{gi}^1M_{gi}^1$, $M_{gi}^2M_{gi}^2$, ..., $M_{mgi}^mM_{mgi}^m$, i = 1, 2, ..., n.

Where all the $M_{gi}^jM_{gi}^j$, (j = 1, 2, ..., m) represent triangular fuzzy numbers.

The AHP fusion steps are:

STEP 1:

The fusion value of the synthetic respective domains with the respect to the *i-th* object is defined as:

$$S_i = \sum_{j=1}^m M_{gi}^j * \left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j\right]^{-1} (S_i = \sum_{j=1}^m M_{gi}^j * \left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j\right]^{-1} (1)$$

To obtain $\sum_{j=1}^m M_{gi}^j$,$\sum_{j=1}^m M_{gi}^j$, we perform the fusion operation by adding *m* values for a certain matrix according to the following statement ,

$$\sum_{j=1}^m M_{gi}^j = \left(\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j\right) \sum_{j=1}^m M_{gi}^j = \left(\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j\right) (2)$$

To obtain values,

$$\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j\right]^{-1} \left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j\right]^{-1} (3)$$

perform the fusion addition operation,

$$M_{gi}^j (j = 1,2, \dots, m)\, M_{gi}^j (j = 1,2, \dots, m) (4)$$

thus obtaining values,

$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{n} l_i, \sum_{j=1}^{n} m_i, \sum_{j=1}^{n} u_i\right) \sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{n} l_i, \sum_{j=1}^{n} m_i, \sum_{j=1}^{n} u_i\right)$ (5)

The inverse vector for a given statement is calculated as follows,

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \quad (6)$$

STEP 2:

If $M_1M_1 = (l_1l_1, m_1m_1, u_1u_1)$ and $M_2M_2 = (l_2l_2, m_2m_2, u_2u_2)$ stand for two fuzzy triangular numbers, the degree possibilities $M_2M_2 = (l_2l_2, m_2m_2, u_2u_2) \geq M_1\, M_1 = (l_1l_1, m_1m_1, u_1u_1)$ is defined as:

$$V(M_2 \geq M_1) = \sup_{y \geq x}[min(\mu_{M_1}(x),)\mu_{M_2}(y),]\ V(M_2 \geq M_1) = \sup_{y \geq x}[min(\mu_{M_1}(x),)\mu_{M_2}(y),] \quad (7)$$

An equivalent statement for (7) is given by the following,

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2} = 1\ if m_2 \geq m_1, 0\ if\ l_1 \geq u_2, otherwise\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}$$

$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2} = 1\ if m_2 \geq m_1, 0\ if\ l_1 \geq u_2, otherwise\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}$

$$V(S_b \geq S_a) = 1\ if m_b \geq m_a, 0\ if\ l_a \geq u_b, otherwise\ \frac{l_a - u_b}{(m_b - u_b) - (m_a - l_a)}$$

$V(S_b \geq S_a) = 1\ if m_b \geq m_a, 0\ if\ l_a \geq u_b, otherwise\ \frac{l_a - u_b}{(m_b - u_b) - (m_a - l_a)}$ (8)

STEP 3:

Possibility degree of a convex fusion number to be greater than k , a convex fusion number can be defined as follows:

$$VV(M \geq M_1, M_2, \ldots M_k) = V\,[(M \geq M_1) and\ (M \geq M_2) and \ldots and\ (M \geq M_k)] = min(M \geq M_i), i = 1,2,3, \ldots, k\ (9)$$

$VV(M \geq M_1, M_2, \ldots M_k) = V\,[(M \geq M_1) and\ (M \geq M_2) and \ldots and\ (M \geq M_k)] = min(M \geq M_i), i = 1,2,3, \ldots, k\ (9)$

Supposedly,

$d(A_i) = minV(S_i \geq S_k) d(A_i) = minV(S_i \geq S_k)$, for the $k = 1,2, \ldots, n: k \neq i, = 1,2, \ldots, n: k \neq i,$

the weight vector is given as follows,

$$W' = \left(d'(A_1), d'(A_2), \ldots, d'(A_n)\right)^T (10)\ W' = \left(d'(A_1), d'(A_2), \ldots, d'(A_n)\right)^T (10)$$

Where $A_i (i = 1,2, \ldots, n) A_i (i = 1,2, \ldots, n)$ represents the number of *n* elements.

STEP 4:

In normalization, the normalized weight vectors would be:

$$W = \left(d(A_1), d(A_2), \ldots, d(A_n)\right)^T (11) W = \left(d(A_1), d(A_2), \ldots, d(A_n)\right)^T (11)$$

where *W* does not represent a fuzzy number.

This paper considers attributes as criteria for analyzing the influence of factors on the development of ambient intelligence towards enhancing e-learning as shown in Table 1.

Table 1.

CRITERIA	
C1	Audio-video communication possibility
C2	Possibility for continuous teachers' guidance through teaching content
C3	Environment likewise e-learning system provide conditions for dynamic realization of teaching contents
C4	Multimedia presentation of teaching contents
C5	Teaching content design

Table 2 displays, as an alternative, the teaching environment.

Table 2.

ALTERNATIVES	
A1	Traditional teaching
A2	Hybrid teaching (Traditional and E-learning)
A3	Guided e-learning supported by simulations
A4	Pure e-teaching
A5	Traditional teaching with the use of multimedia content

Upon the implementation of the fusion AHP method as Chang's analytical method [14], we come to results as shown in Table 3:

Table 3.

CRITERION	WEIGHTED VALUES	ALTERNATIVES				
		A1	A2	A3	A4	A5
C1	**0.14368**	0.237334	0.202872	0.225072	0	0
C2	**0**	0.109059	0.151158	0.130807	0.021366	0.11039
C3	**0.26754**	0.34287	0.303967	0.319555	0.38745	0.36427
C4	**0.22053**	0.154462	0.201578	0.148429	0.38745	0.36427
C5	**0.36825**	0.156274	0.140425	0.176136	0.203734	0.16105
WEIGHTS OBTAINED		**0.217443**	**0.206638**	**0.215428**	**0.264128**	**0.23710**

Table 3 allows us to come to the conclusion that criterion C3 "Environment and e-learning system provides conditions for the dynamic realization of teaching content" is weighted by the highest value while criterion C2 "Ongoing teachers' guidance through teaching content" is weighted by the lowest value. In order to determine the value of alternatives, a convergence consensus model has been applied in this paperwork.

The consensus convergence model [15] has been developed for the sake of decision making on the effectiveness of ambient factors regarding students' achievements within the e-environment. This model is based on determining the differences in the "weights" of decision-makers on the basis of values assigned by each decision-maker to relevant elements (criteria, sub-criteria, and/or alternatives) [16]. Table 4 displays the calculated values of alternatives.

Table 4.

ALTERNATIVES	CONSENSUS WEIGHT VECTORS	RANK
A1	0,060	5
A2	0,069	2
A3	0,077	1
A4	0,061	4
A5	0,062	3

Based on the calculation, we can conclude that the alternative A3 "Guided e-simulation-supported teaching" is ranked first regarding the importance of the effective development of ambient intelligence in order to enhance e-learning.

Identification and security context analyses

Identification context implies observational procedures relating to the notification of students' reactions to the created teaching content likewise the teaching process.

Security context implies defining procedures that minimize the possibility of teaching content as well as users' personal information misuse.

Stated contexts in this paper have been analyzed by the same method as the context of the environment for e-learning with the maximum assurance of the prescribed quality of e-learning standards [17].

An alternative to the emerging value identification context is "Guided e-simulation-supported teaching". An alternative with the highest possible value for context security is "Traditional teaching using multimedia".

Criteria considered for all three contexts are: C1-Possibility of audio-video communication, C2-Teachers' ongoing guidance through the teaching content process, C3-Both e-learning environment, and e-learning system provides conditions for the dynamic realization of the teaching content, C4-Multimedia syllabus presentation, C5-Teaching content design.

Comparative analyses have found that "Guided e-simulation-supported teaching" represents the optimal environment for e-learning. Considered criteria are the basics for the development of ambient intelligence.

Required and sufficient conditions for the C1 criterion "Audio-video communication possibility" can be the existence of compatible audio-video equipment for teachers as well as for students.

Required and sufficient conditions for criterion C2 " Possibility for continuous teachers' guidance throughout teaching content" can be: installed interactive platform which is able to track students' work, and of course, when needed, informs the teacher regarding the difficulty in mastering the teaching content.

Required and sufficient conditions for C3 criterion " Both e-learning environment and e-learning system provide conditions for the dynamic realization of the teaching content " can be the existence of e-learning platform as well as appropriate microclimate conditions towards the realization of dynamic content and sensors installed for monitoring basic parameters of general conditions like students' pulse, temperature, blood pressure, etc.

Required and sufficient conditions for the C4 criterion "Multimedia syllabus presentation" can be: the existence of e-platform which allows you to create, set up, or use the multimedia presentation of teaching content.

Required and sufficient conditions for C5 criterion "Teaching content design" can be the existence of an e-platform which enables the design of teaching content according to the topics as well as the timing of a teaching process.

Ambient intelligence shall be developed throughout these contexts with the use of a neural network whose final result will be expressed through the fusion of neural network results, observed for each criterion individually. Basic connections within the system for the development of ambient intelligence are presented in Figure 1.

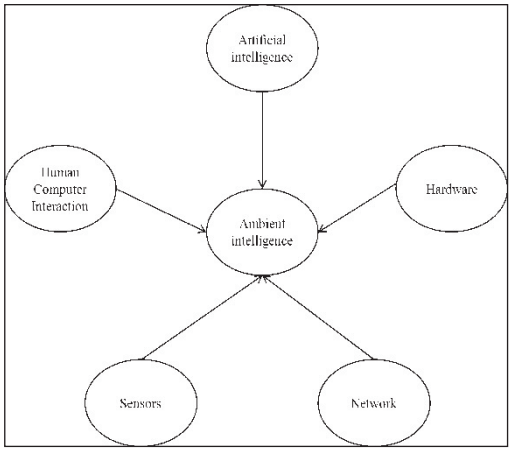

Figure 1: *Connections in the ambient intelligence development system*

This paper will explain the neural network model used for criterion C1 "Audio-video communication possibility".

Video equipment should allow the monitoring of students' facial expressions. Based on these expressions, the system will propose corrective actions within the ambient environment. For this purpose, Convolution neural networks models will be used, also known as non-cognitive models [18]. For the sake of analyses, these models will use data deployed in advanced databases [19].

Convolution neural networks

This term "Convolution neural networks" is in correlation with convolution, respectively operator, used in image and signal processing [20]. We use convolution filters in the field of artificial intelligence and neural networks to sharpen or blur images likewise to detect edges in contrasting terms.

Convolution neural networks are most frequently used when data represent images that are pixel matrix and they are presented by their width, height, and pixel values. For color images, each of the three "RGB" channels is usually represented by value pixels within the range 0-255.

In convolution neural networks, the convolution filter represents a generalized linear model for the image region to which it is applied [21]. Apart from the filter name, the context of convolution neural networks, the name convolution kernel is also used. The filter is represented by a two-dimensional matrix of small dimensions, compared to the image to which it is applied and is consisted of real values.

An important concept of convolution neural networks is displayed in maximal compression as a form of nonlinear pixel reduction [22]. Depending on a compression type, a pixel with a particular value in a particular region is selected. As for reduction operation, the pixel with the highest value is chosen for the maximum. The compression layer is used to reduce progressively the size of the image and therefore the number of features, thus leading to a decrease in the complexity of the calculation. An example of maximum compression is shown in Figure 2.

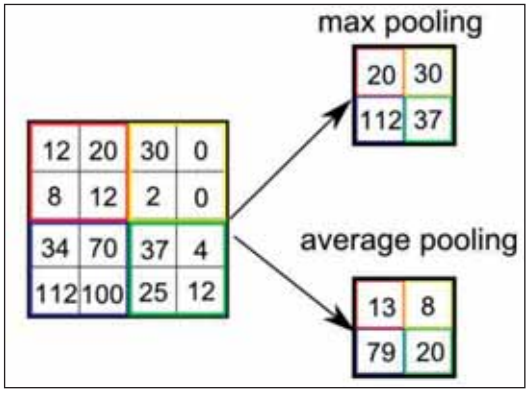

Figure 2: *Example of maximum compression*

Description of the general architecture relating to convolution neural networks.

The difference of convolution neural networks about other types of architecture neural networks reflects in the existence of a layer where convolution occurs. Convolution layer is essential for the functioning of a convolution neural network. It also performs various demanding calculations [23,24,25].

The essence of using convolution neural networks is to enable the response in real-time regarding activities that take place in distance learning systems [26,27,28,29].

Figure 3 shows the architecture of convolution neural networks.

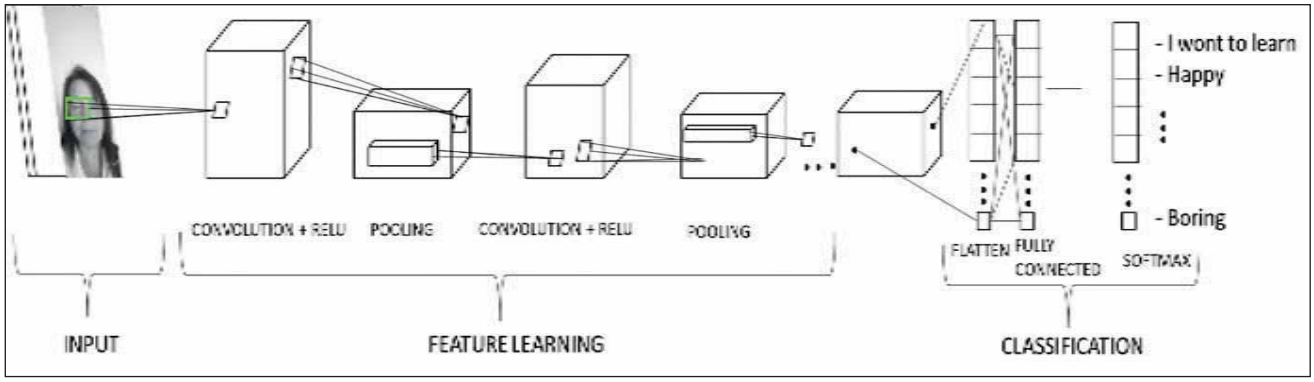

Figure 3: *The architecture of convolution neural networks*

The initial author used to construct and recognize facial expressions with the use of his photos as input data towards processing within convolution neural networks. The initial author of the paper has also tried to present different states of facial expressions as shown in Figure 4.

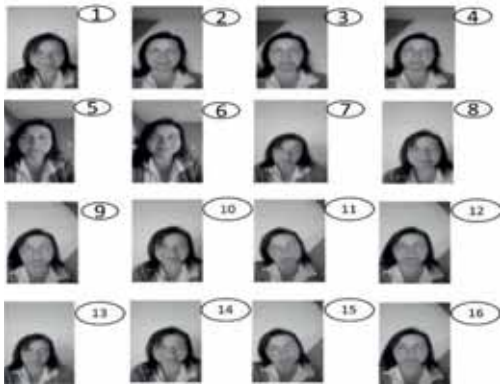

Figure 4: *Different facial expressions*

Position 8 in figure 4 shows the state in which the person expresses disinterest in teaching activities, manifested by eyes closed as well as lips folded. The lack of interest in teaching activities can be a consequence either of fatigue or poor ambient conditions.

To compare the results of artificial neural networks, comparative analyses of the obtained values for the criterion C1 has been conducted by the author. The analyses are the result of image processing via convolution neural networks likewise through artificial "backpropagation" neural networks of which activation function is the sigmoid function. For the research, Neuroph studio has been used in which neural network has been created as shown in Figure 5.

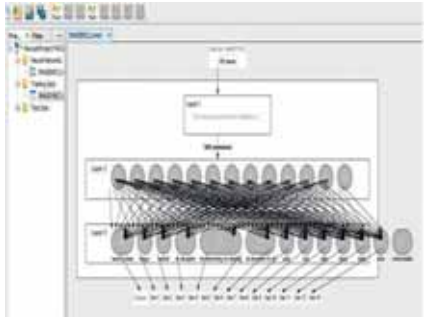

Figure 5: *A neural network created in a Neuroph studio*

After 10000 interactions, an error value of 0.01 has been reached while in Figure 6 a graph of the total network error after 136 interactions is shown.

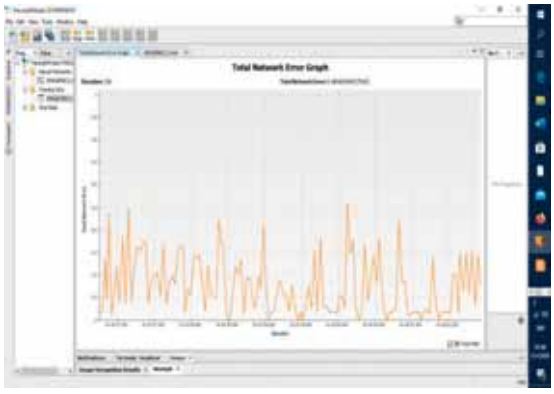

Figure 6: *Total network error graph after 136 interactions*

RESULT

During the testing of the convolution neural network, facial expression detection has been performed, relating to disinterest in teaching in 97,7 percent of cases based on 16 different facial expression images.

By testing artificial backpropagation of a neural network whose activation function is sigmoid recognition of facial expression, detection of facial expression relating to disinterest in teaching in 87,7 percent of cases has been conducted, based on 16 different photos of facial expressions.

Further development of the e-learning platform should provide the teaching staff with information on which corrective measures should be taken to create ambient conditions to achieve better results in mastering the curriculum.

The initial author, Maths professor, has applied corrective methods within the organization of e-teaching for the sake of mathematics course, which implied a higher level of achievement in ambient students' intelligence in comparison with students taught traditionally.

DISCUSSION

Ambient intelligence evolves through contexts: e-learning environment, identification, and security.

This paper displays the influence of the e-learning environment through the criterion C1 "Audio-video communication possibility" where sufficient as well as required conditions are listed as the existence of installed compatible audio-video equipment for students likewise for teachers.

Survey results indicate that with the use of ambient intelligence better results are achieved, especially in elementary schools mathematics.

CONCLUSION

Contemporary trends, as well as lifestyles, are increasingly suggesting that e-learning will be applied on a much larger scale in comparison to the traditional way of schooling. Suppose that we see learning as a type of business or production, the final product represents knowledge, we have to be objective and conclude that in case the final result is good, the production system will be simpler and cheaper. Therefore, there is no reason not to accept it.

Research results indicate that the convolution neural network is more suitable for facial expression recognition in comparison with artificial backpropagation neural networks.

Modern information technology in the creation of ambient intelligence has a key role in raising students' achievements as well as competency levels. It is also being executed through the concept of e-learning onto one of the convenient learning management platforms.

Research results also indicate that with the use of ambient intelligence, better results are achieved, especially in elementary school mathematics education.

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