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Determining of The Achievement of Students by Using Classical and Modern Optimization Techniques

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The purpose of this study is to investigate effects of sleeping hours and study time on students' achievement and to find at which points the minimum and maximum achievement level occurs. Participants of this study are 8th grade students who are students of a public secondary school in Isparta, Yenisarbademli. 12 students participated in this research. Results of five trial exams that students were used in order to determine achievement levels of students. The data for students sleeping hours and study time emerged from interviews. During the interview, students were asked about that their sleeping hours and study time of in a week period before each exam. Data that emerged from interview were categorized by the researcher. Data were evaluated using MATLAB 7.012. (R2011A). In this study, minimum and maximum points were identified using global optimization methods.

Keywords: mathematical modelling, fuzzy logic, elementary education

INTRODUCTION

Learning is a lifelong process of transforming information and experience into knowledge, skills, behaviour, and attitudes. Acquisition of knowledge in courses, such as mathematics, Turkish and social sciences is a learning process. If learning occurs, it means there is success. Success can be defined as achieving a desired result. Success in academic life means successfully reflecting mental activity in performance. The reflected performance needs to be accurately measured. For this purpose, different measurement and assessment tools such as multiple choice test, essay type exams, true false items test are used.

It may not be possible to measure an individual's academic success, because an individual may not transform all his/her learning to performance. There may be many different factors that affect reflection of learning outward. Conducted research shows that there are various dimensions to these factors. These dimensions include intelligence, variables, such as the student's cognitive development level and

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learning styles, as well as organizational and environmental factors.

Sleeping hours is the most effective health behaviour that affects academic success. Studies which investigate relation of sleeping hours and academic achievement show that having sufficient sleep has a positive effect on academic achievement (Keskin 2009; Koçoğlu 2010). In this study, students wrote down when they went to sleep and when they woke up. The purpose of this study was to investigate the effect of sleeping time on academic achievement. Study is defined as a reading frame. Studies which investigate academic achievement, it has been carried out different age groups (elementary, high school and university students) (Özcan 2006; Şener 2001). Results of these studies show that study habits have an effect on academic achievement, and focus of the research show that successful students have more effective study habit. Data gathered from these research show that students in our country do not have effective study habit or they have medium level study habit (Özcan 2006; Keskin 2009).

Mental activity is an outward reflection of the successful. Child's academic success is a multi-component case. Many factors such as hereditary characteristics, parental expectations and appropriate work habits affect efficacy in academic achievement. In this study, the effects of sleep and study time on academic achievement were investigated.

Fuzzy logic was first introduced by L. A. Zadeh in 1965 (Zadeh 1965, 1973, 1975).The concept of fuzzy logic is based on the fuzzy set. The concept of the fuzzy set is a set whose elements are binaries consist of a point and the belonging possibility of the point to the set. According to this view, fuzzy sets don't have certain boundaries. Zadeh and the other authors enriched the theory of fuzzy logic in 1985. Mamdani used fuzzy logic in a real world problem to control dynamic systems (Mamdani 1974). After that, Sugeno and others tried to extend the application areas of fuzzy logic (Takagi 1985, Sugeno 1985). Recently, fuzzy logic was used in many areas of engineering, physics, chemistry, education and etc. (Chai 2009; Mamdani 1975; Karagoz 2014).

In the literature, when the studies on the application of fuzzy logic was examined, two types of Fuzzy Inference Systems (FIS) Mamdani and Takagi-Sugeno were distinguished, clearly. It has been argued that, each of these FIS outmaneuver each other from time to time but there is no exact result showing the superiority of one of them. We selected the Mamdani type FIS since the usage of the Mamdani type is easy. The enriched data were used for surface fitting to obtain a continuous objective function. Surface fitting is special form of curve fitting. The aim of using surface fitting is to determine the continuous function that is best represented the data collection (Arlinghaus 1994; Kolb 1984).

Our main aim is to determine the conditions that maximize academic achievement. We used FFM to realize this work. FFM is one of the global optimization techniques and it was proposed by R. P. Ge (Ge 1987, 1990). This method aims to find the lower minimizer than the known, first minimizer by the help of an auxiliary function with certain properties. The lowest minimizer (global minimizer) is found by the iterations of the above process. Although, many studies related to theoretical structure of the method (Liu 2001, 2002; Şahiner 2012), there exist few studies on the application of the FFM to real world problems (Şahiner 2012; Center 1998).

MATERIALS AND METHODS

Data Collection

This study was carried out in the second period of the 2013-2014 academic year. Participants of the study are eighth grade students of Yenisar bademli, Fatih

Secondary School in Isparta. In this study, the effects of sleep and study time on academic achievement were investigated. Study time and sleep time were selected as inputs and academic success has selected as an output. Students wanted to wrote down sleeping time and study time. Data of students' sleeping time and study time were gathered just one week before students took multiple-choice exams. Collected data were evaluated. In this study, the effects of sleep and study time were investigated. Students' multiple-choice test results were taken as sign of students' academic achievement level.

Socioscientific issues

The construct of socioscientific issues (SSI) currently constitutes the most prominent approach regarding the integration of ethical aspects into science lessons (Ratcliffe & Grace, 2003; Sadler, 2004; Zeidler, Sadler, Simmons, & Howes, 2005; Sadler & Donnelly, 2006; Sadler, 2011a). The term refers to issues that originate from science but always include a social or societal dimension. Thus, they cannot be solved with scientific methods only. Such issues are characterized by the connection of scientific concepts and ethical values and their weighting. According to Sadler (2004; 2011a) SSI are social dilemmas, which contain either conceptual or technological links to one or more fields of science. Topics, which depict SSI are, e.g., global climate change, cloning or stem cell research (cf. Sadler, 2004). SSI are always complex. Their complexity is caused by the necessary consideration of knowledge from different domains and by the obligatory inclusion of ethical values (Kolstø 2001, Zeidler & Sadler, 2007). Furthermore, those issues are "open-ended, often contentious dilemmas, with no definitive answers" (Sadler, 2004, 514). Zeidler and Nichols (2009, 49) add that SSI are controversial and "have the added element of requiring a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues." The goal of including ethical aspects into science lessons through the treatment of SSI is to empower "students to handle the science-based issues that shape their current world and those which will determine their future world" (Sadler, 2004, 514). The treatment of SSI in science lessons is supposed to enhance the connection of scientific facts with students' everyday life and thus making science for students more relevant (Zeidler & Nichols 2009; Hostenbach, Fischer, Kauertz, Mayer, Sumfleth, & Walpuski, 2011). Furthermore, SSI foster students to acquire argumentation skills (Zeidler & Nichols, 2009), which constitute important requirements for taking part in public discourse as a full member of a democratic society.

Sadler et al. (2007) identified four characteristics of decision-making regarding SSI. When dealing with SSI students should be able to a) recognize the complexity of SSI, b) examine the given issues under the consideration of multiple perspectives, c) appreciate that SSI can be subject to enduring inquiry ("science-in-the-making"; Kolstø 2001) and d) exhibit skepticism regarding available information.

Fuzzy Logic Approach

As was mentioned above, fuzzy logic modelling starts with the concept of a fuzzy set. A fuzzy set is a set without a crisp and clearly defined boundary. Assume X is an ordinary set, whose elements are denoted by x (Zimmermann 2010). Membership in an ordinary subset A of X can be expressed by the characteristic function,$\mu_A$from X to {0, 1} such that:

Definition 1: If X is a collection of objects denoted generically by x, then a fuzzy set A in X is a set of ordered pairs:

$$A= \{(x,)\ \mu_A(x)\ |x \in X\}$$

μ_A(x) is a membership function and it takes values between 0 and 1. If there exists an element x_0 such that μ_A(x) =1, then a fuzzy set is called normal.

Definition 2 :(Convex fuzzy set) A fuzzy subset A of X is called convex if $[A]^{\alpha}$is a convex subset of X, ∀α∈ [0, 1].

Definition 3: Let A be a fuzzy subset of X; the support of A, denoted supp(A), is the crisp subset of X whose elements all have nonzero membership grades in A.

Supp (A) = {x ∈X|μ_A(x) > 0}.

A fuzzy set A is called a fuzzy number if the following properties holds:

a. A is normal,

b. A is fuzzy convex, i.e. μ_A(x) (λx_1+ (1-λ) x_2) ≥μ_A(x) (x0) ∧μ_A(x) (x_2) (∀x_1, x_2∈R, λ∈ [0, 1]),

c. μ_A(x) is upper semi-continuous,

d. supp (A) is bounded, where supp (A) =cl ({x∈R:μ_A(x)>0}) and cl is the closure operator.

A fuzzy number can be defined in fuzzy systems by triangular fuzzy and trapezoidal membership functions.

a_1, a_2, a_3∈R and (x, μ_A(x)) ∈A is called a triangular fuzzy number if its membership function has the following form:

$$\mu_A(x) = \begin{cases} 0 \quad , \quad x < a_1 \\ \dfrac{x - a_1}{a_2 - a_1} , a_1 < x < a_2 \\ \dfrac{a_3 - x}{a_3 - a_2} , a_2 < x < a_3 \\ 0, x > a_3 \end{cases}$$

a_1, a_2,a_3,a_4∈R and (x, μ_A(x))∈A is called a trapezoidal fuzzy number if its membership function has the following form:

$$\mu_A(x) = \begin{cases} 0 \ , \quad x < a_1 \\ \frac{x-a_1}{a_2-a_1} , a_1 < x < a_2 \\ 1 \ , < x < a_3 \\ \frac{a_4-x}{a_4-a_3} , a_3 < x < a_4 \\ 0, \ x > a_4 \end{cases}$$

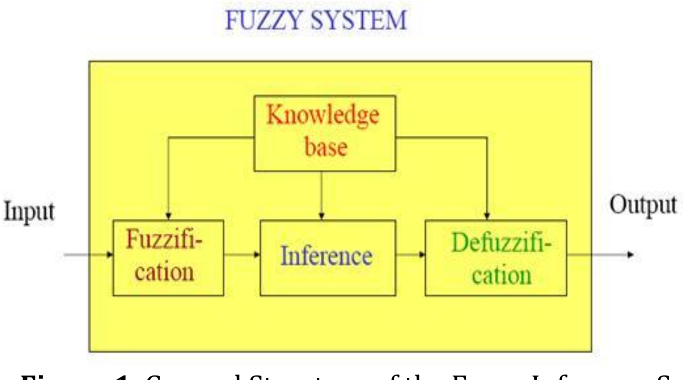

Figure 1. General Structure of the Fuzzy Inference System

Now we continue with defining the basic elements of the FIS. Each FIS consist of fuzzification, inference engine and defuzzification stages (see Fig. 1.). In the fuzzification stage, the crisp values becomes fuzzy values and the membership functions μ_A(x) are defined for the inputs and outputs. There are different types of membership functions: Triangular, trapezoidal, Z-shaped, Gaussian, sigmoidal, S-shaped. We used triangular and trapezoidal membership functions in this study.

For the inference engine, the linguistic rules "if… then…" are determined which are commands of the system behavior. These rules set down the relations between inputs and outputs. In the fuzzy logic system, there are different types of membership functions: triangular, trapezoidal, Z-shaped, Gaussian, sigmoidal, S-shaped. We used triangular and trapezoidal membership functions in this study.

At the last stage (defuzzification), fuzzy values become crisp values. There are different types of defuzzification methods such as: centroid, bisector, middle of maximum (mom), smallest of maximum (som), and largest of maximum (lom). We preferred centroid technique for this study.

The Determination of the Objective Function

Curve fitting is the process of constructing a curve, or a mathematical function, that has the best fit to a series of data points. If the data are 3-dimensional, the name of this process will be surface fitting. Curve fitting or surface fitting includes the exact fitting to the data, or constructing the smooth and approximate fits to the data. Fitted curves or surfaces can be used as an aid for data visualization, to get an information about the values of a function where no data are available, and to take a first impression referring to the relationships among the variables. We use MATLAB 7.12.0 (R2011A) Surface fitting toolbox to realize these processes.

Filled Function Method

The filled function method is one of the global minimum finding techniques. It is operational for the objective function f on R^n, under the following conditions:

(i) f is Lipschitz continuous on R^n,

(ii) f has only a finite number of minimizers,

(iii) $f(x) \to \infty$ as $\|x\| \to \infty$.

According to condition (ii) the number of local minimizers of f must be finite. The value of local minima can be infinite. Now, we give some descriptions of the filled function method.

Definition 4: $p(x,x^*)$ is called a filled function of f(x) at a local minimizer x^* if $p(x,x^*)$ has the following properties:

i. x_k^* is a local maximizer of $p(x,x^*)$,

ii. $p(x,x^*)$ has no stationary point in the region

$S_1 = \{x \in R^n : f(x) \geq f(x^*)\}$

And,

iii. If $x^*$is not a global minimizer of f(x), then $P(x,x^*)$ does have a minimizer in the region

$S_2 = \{x \in R^n : f(x) \leq f(x^*)\}$.

In terms of the above properties of a filled function, any of the descent methods, for example the steepest descent method, the Newton method, the conjugate gradient method, etc., is employed to find the local minimizer x_1 of the objective function f. Thereafter, the filled function is constructed. This function contains objective function in its formula and has a maximizer at a point x_1. The sequence of iteration will not terminate at any point inW_k^*, and when there exists basins of filled function, lower thanB_k^*, the sequence will either terminate at a point in basin lower than B_k^* or generate a point $x_s$such that the value of f (x_s) is less than $f(x_1)$.The above process is repeated until the global minimizer of f is found..

APPLICATION OF SUGGESTED TECHNIQUES

Application of Fuzzy Logic

The parameters sleep time and study time are affected by academic achievement. To set up a model, we built a fuzzy logic model whose input variables are sleep time and study time and the output variables is academicachievement. The general structure of the model is shown in Figure 2.

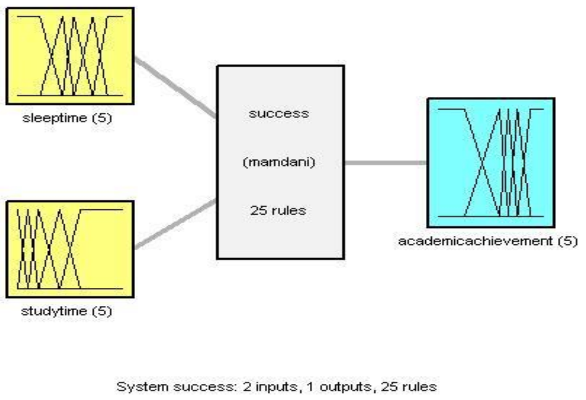

Figure 2. General Structure of our Fuzzy Logic Model

Fuzzy logic shows experience and preference through its membership functions. Sleep time was classified as very little(vl), little(l), normal(n), much(mu), between 0 and 6 hours is very little, between 6 and 7.5 hours is little, between 7.5 and 10 hours is normal, between 10 and 12 hours is much, between 12 and 14 hours is very much. Study time was classified as very little (vl) little (l), normal (n), much (mu), verymuch (vmu), between 0 and 1 hours is very little, between 1 and 2 hours is little, between 2 and 4 hours is normal, between 4 and 6 hours is much, between 6 and 10 hours is very much. These statements were mathematically modelled by fuzzy sets, as shown in Figures 3, a, b respectively.

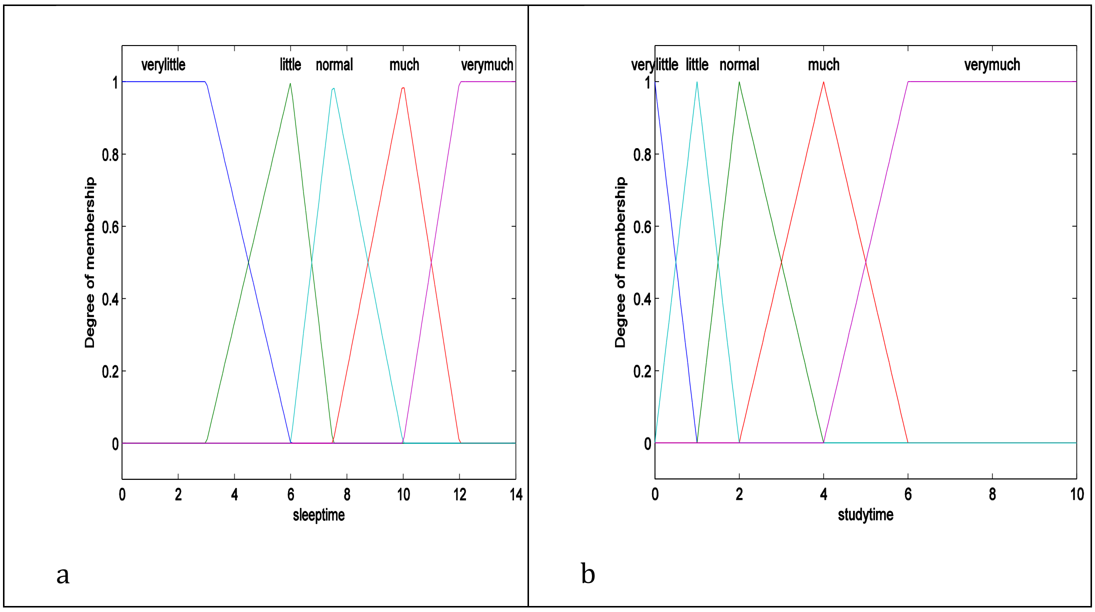

Figure 3. The membership functions for sleep time (a) and study time (b)

Then the output of academic achievement was classified as very little (vl), little (l), normal (n), much (mu), verymuch (vmu) and between 0 and 70 is defined as very little, between 70 and 80 is defined as little, between 80 and 90 is defined as normal, between 90 and 105 is defined as much and between 105 and 120 is defined as very much. These statements were mathematically modelled by fuzzy sets, as shown in Figure 4.

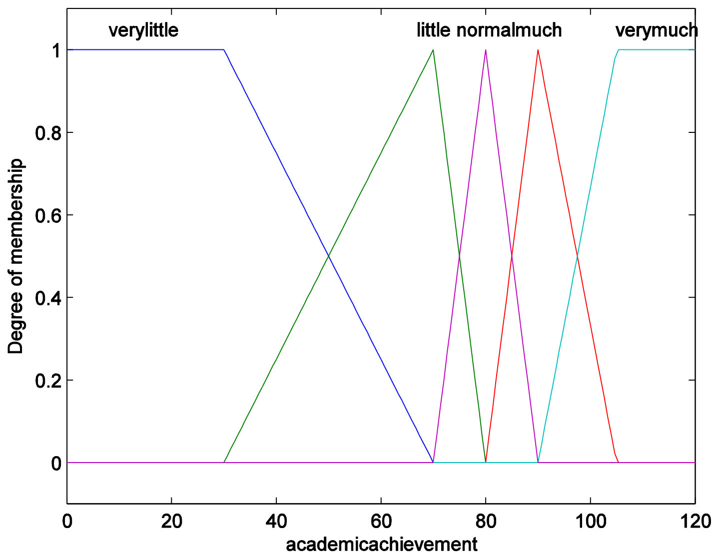

Figure 4. The membership functions for academic-achievement

The rule structure is designed based on how the experts interpret the characteristics of the variables of the system. It is possible to write down a lot of "if-then" fuzzy rules and some of the rules used in the model are as the following:

If (sleeptime is verylittle) and (studytime is little) then (academic achievement is little)

If (sleeptime is little) and (studytime is little) then (academic achievement is normal)

If (sleeptime is little) and (studytime is much) then (academic achievement is normal)

If (sleeptime is normal) and (studytime is verylittle) then (academic achievement is verylittle)

If (sleeptime is normal) and (studytime is normal) then (academic achievement is normal)

If (sleeptime is normal) and (studytime is much) then (academic achievement is very much)

If (sleeptime is much) and (studytime is little) then (academic achievement is little)

If (sleeptime is much) and (studytime is much) then (academic achievement is much)

⋮

After the simulating Mamdani method the surfaces for academic achievement accordance with the constructed model, is plotted in Figure 5

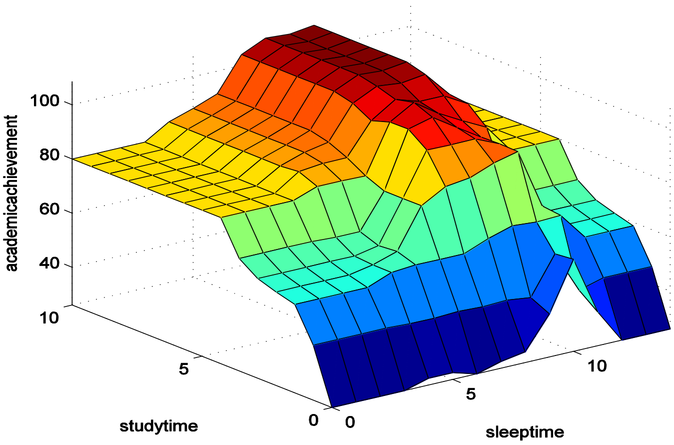

Figure 5. The graph of the function that is obtained from fuzzy logic modelling

The correlation coefficient R^2 which is obtained by regression analysis shows that the experimental results and fuzzy logic results of academic achievement are close to the rate of 93 %.(Figure 6)

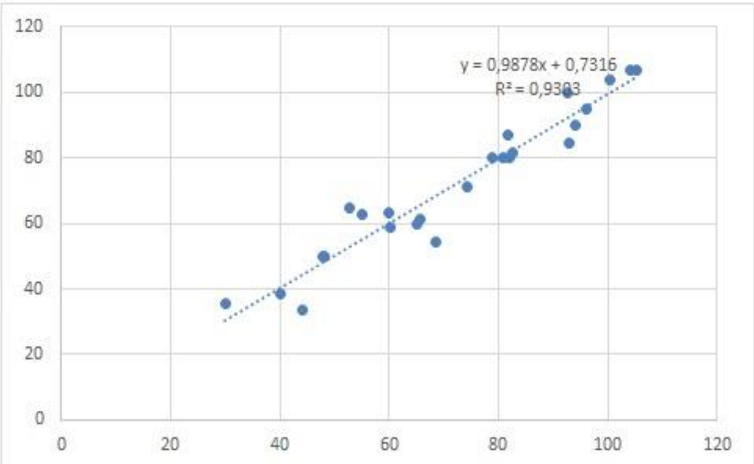

Figure 6. Comparison of the experimental and fuzzy estimated values

By considering the fuzzy logic approach, maximum success is obtained by sleeping 9.05 hours and studying 6.614 hours or by sleeping 8.84 hours and studying 6.614 hours as a 105.2 nets.

Setting the Objective Function and Application of FFM

Sofar we just have discrete data which are enriched by fuzzy logic modeling. But to apply FFM we need a continuous (in fact continuously differentiable) objective function. In this study, we use one of the surface fitting techniques to construct the objective function and we obtain the following objective function:

Now we just have enriched data by fuzzy logic we need to set up the objective function. For filled function method. To set up the objective function, enriched data is used in the surface fitting techniques to obtain the following objective function.

$$f(x, y) = -189.6+11.91\sin(-0.01207\pi x.y)-0.7197x^2+36.11y-0.1426y^3$$
$$-48.82\exp(-39.81x)+156\exp((0.1809y)^2)+15.04x-0.01207x^3+4\cos y$$

The graph of the function f can be seen at the Figure 7.

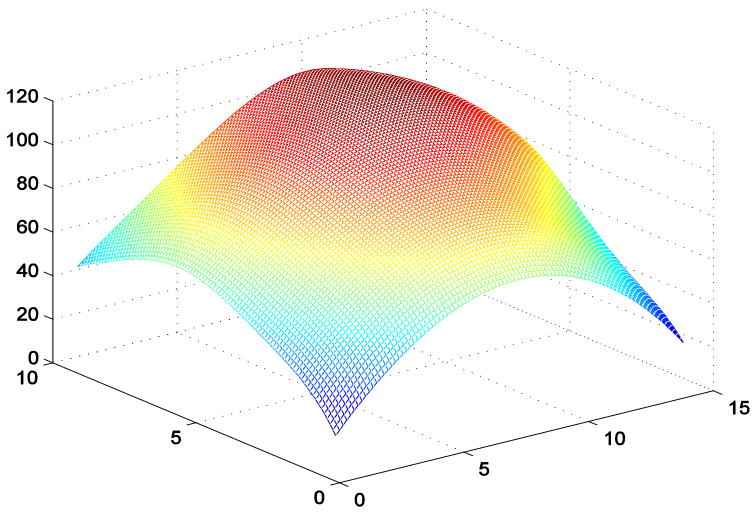

Figure 7. The graph of the function that is obtained from surface fitting

In order to find the global maximizer of the function f, we use the filled function S (Şahiner 2012)

$S(x, x_1^*, a) = -\|x - x_1^*\| + a \max\{0, f(x) - f(x_1^*)\} + \eta(\min\{0, f(x) - f(x_1^*)\})$,

Where a is parameter and η is mitigator function. η (t) =arctan(t) or η(t)=ln(1+t) and following algorithm:

Step 0. Determine $\varepsilon=10^{-4}$, $a=-10^{-2}$, D= region, x_0= starting point

Step 1. Find the first local minimizer x_1^* of the objective function f(x) starting from the point x_0.

Step 2. Build the filled function at the point x_1^* and employ a local minimization method starts from x_1^*, to get a local minimizer of filled function denoted x_1.

Step 3.

(i) If the point x_1 is a minimizer of any of the filled function, then go to Step 4.

(ii) If the x_1 is an element of the boundary of the D, then stop and the x_1 is the global minimizer.

Step 4. Consider the point x_1 as the starting point, employ a local minimization method to find another local minimizer x_2^*. (If it exists and different from the x_1^*)

(i) If f (x_2^*) <f (x_1^*), update x_2^* by x_1^*, then go to Step 3.

(ii) If f (x_2^*)>f (x_1^*), unchanged the x_1^* but update the parameter (replaced by $a+10^{-3}$) and go to Step 2.

Moreover, we use the following filled function and its minimization algorithm proposed by Zhang (Zhang 2004).

$p(x,x_1^*,\rho,\mu)=f(x_1^*)-\min\{f(x),f(x_1^*)\}-\rho\|x-x_1\|^2+\mu[\max\{0,f(x)-f(x_1^*)\}]^2$

Where ρ and μ are parameters. Both of the algorithms depend on minimization of the given objective function. If anyone takes -f and finds its global minimizer x^* then, the global maximizer of f is x^*.

As a result, by considering the above classical optimization process the maximum success is obtained by sleeping 10.217 hours and studying 7.72 hours by using both filled functions S and p. The maximum value of the students' achievement is 110.5 nets.

CONCLUSION

In this study, we used fuzzy logic and filled function method and examined the effects of study time and sleep time to academic achievement. It is found that high levels of academic achievement can be obtained by a normal level of sleeping time with very much study time by considering the fuzzy logic approach. By considering the above classical optimization technique 110.5 is obtained if the sleep time is 10.217 hours per day and study time is 7.72 hours per day. This study is a pioneer for application of both modern and classical optimization techniques to the evaluation of achievement test for students.

For future work: Since there are many different factors that effect learning, any other studies can be conducted by changing the input factors. Different types of modeling techniques can be applied to these kinds of problems and comparison of these modeling techniques can be investigated. Moreover, the proposed methodology can be effective for large data sets in terms of the certainty and reliability of the results.

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