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SPECIAL SECTION ON NEW TRENDS IN BRAIN SIGNAL PROCESSING AND ANALYSIS

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An Intelligent Assistive Tool Using Exergaming and Response Surface Methodology for Patients With Brain Disorders

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ABSTRACT Intelligent assistive technologies represent a concept that refers to products and services that can offset functional limitations, facilitate independent life, improve their quality of life, and enable people with disabilities to reach their own potential. This paper presents a medical recovery exergaming that includes a Microsoft Kinect Motion Sensor, designed for upper limb rehabilitation, especially for old people with brain disorders. The game is 3D and during the game, the user has to pick up the red or green apples according to a level, and different angles of inclination of the neck, hand, shoulder, and so on are measured and then a total score is generated. To know if the patient has progressed in his medical recovery, the final score should be increased. In order to find the score that a subject without a locomotor system disorder can achieve, we have optimized the game with mathematical modeling and canonical analysis by applying response surface methodology and multiple nonlinear regression. The exergaming based on VR active games represents a useful tool in physical and cognitive rehabilitation for people with motor impairments or brain disorders, considering the advantage of home-training.

INDEX TERMS Intelligent assistive technologies, response surface methodology, exergaming, rehabilitation, brain disorders.

I. INTRODUCTION

Nowadays, the Intelligent Assistive Technologies (IAT) may assist people (e.g. elderly people with disabilities or brain disorders) to lead a complete and independent life, and according to the WHO (World Health Organization) [1], about one billion people need access to programs on improving rehabilitation using assistive technologies. Active aging is the process by which elderly people are encouraged to remain in the workplace and share their experience with other generations. At the same time, it involves encouraging the seniors of society to volunteer in various cultural, community and economic activities that contribute to the development of the community. Unlike previous decades, the elderly population has the chance to live longer, which gives it the chance to remain active in society to fulfill its goals and expectations. In some countries of the European Union, various programs are already developed to adapt the professional capacities of elderly people in order to be easily integrated into the labor market or to remain professionally active for a long time. Developing strategies to promote active aging and intergenerational solidarity will increase between 2010 and 2020, being one of the main themes of the agenda of the European Union [2]. These strategies will focus on the following objectives: reducing the barriers imposed on the elderly to the labor market; changing the attitude regarding the retirement age and the retirement period (additional income can be added by continuing the professional activity); creating an age-friendly policy; changing the perception of older people and their capabilities by younger generations.

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Dementia is not a condition in itself, but a group of manifestations that betray the decline of the mental functions (e.g. memory disorders, thinking, language, behavior) that can be produced by a heterogeneous group of diseases and pathological conditions. In most cases, they are incurable, their progress worsening over time, and can only be slowed down for a limited period of time. It should be noted from the outset that not any such modulation - for example, a decrease in memory or its speed of execution - is the sign of dementia, but only when the mental disorders concerned harm daily life to the level of loss of independence personal. The disease occurs in the vast majority of cases in the elderly. If at 60 years dementia affects just over 1% of the population, the number doubles every five years, so at 85, 40% -50% of people are affected by the disease [2]. In the US, 6 million people are diagnosed with dementia, of which 1.5 million have a severe form [1]. The most common cause of dementia is Alzheimer's disease, which accounts for 50% -60% of cases [1]. But it often happens that a patient has an association of generative conditions (e.g. Alzheimer's and vascular dementia or Parkinson's disease).

The recent developments in Information and Communication Technology (ICT) promise an improvement of physical and cognitive rehabilitation using therapy based on exergaming and augmented reality [3]–[5]. A serious game uses a platform that includes a MS Kinect^{TM}sensor added to an Xbox^{TM} console in order to turn the classic exercise into active video games [6]. The use of the Microsoft Kinect^{TM}sensor has contributed to opening a way in how user interaction technology facilitates and complements the medical applications including physical and cognitive rehabilitation. The therapy using exergaming has the potential to help patients with arthritis and disabilities [7], and also elderly patients with dementia.

In this work, a Kinect medical rehabilitation platform based on exergaming, is presented. The exergaming is implemented for upper limb rehabilitation and can be used in therapy-based game for older adults with brain disorders. The paper is organized as: Section I presents a short introduction about Intelligent Assistive Technologies, ICT, exergaming and therapy-based game for older adults with brain disorders; Section II covers the previous research and related papers; Section III deals with the methods used in this research meaning the response surface methodology in software tools optimization for medical rehabilitation; Section IV presents measurement system analysis; Section V covers the experimental results and discussions; Section VI provides the conclusions and future scope of the research.

II. PREVIOUS RESEARCH

The current research in ICT and Internet of Things (IoT) is focused on developing the real-time monitoring of patient's health using various intelligent assistive devices [8]. According to authors Da Gama et al. in article [9], a systematic research was carried out in the IEEE Xplore and PUBMED databases using the keyword combination "KINECT and rehabilitation" and a number of 109 articles were found in the database research, of which 31 were included in the review: 13 were focused on the development of rehabilitation assistance systems, 3 on medical recovery assessment, 3 on applicability, 7 on KINECT anatomy validation and clinical assessment, and 5 on patient's quality of life improvement techniques [7].

The Professor Octavian Postolache (co-author of this paper) (see [10]–[20]), from the Institute of Telecommunication from Lisbon, Portugal, and his team of researchers have developed and tested applications in the field of medical rehabilitation within the "Smart Sensors and Tailored Environments for Physiotherapy" project [10].

The overarching objective of our research (see [21]–[26]), was the development of new and unique clinically systems for monitoring, staging, and screening of Parkinson's Disease (PD) patients, because currently, there is no clinically approved automatic system for PD monitoring. EEG and tremor signals, handwriting, gait and video information were combined for PD diagnosis, therapy, and rehabilitation. Chiuchisan *et al.* [21] presented "a system for Neurological Disorders Screening and Rehabilitation that manages data acquired from patients with Parkinson's disease in order to support physicians in diagnosis, treatment, and home-monitoring and also to facilitate the interaction at distance between specialists and patients" [21]. Another healthcare system for monitoring patients at fall risk in a smart environment that can be used in an Intensive Care Unit, was presented in [22] and [23], "The system included an intensive care unit bedside monitors in order to monitor and record multiple physiological parameters of patients, the MS Kinect sensors to monitor the movement of the patients to eliminate the situations in which the patient has removed from the sensing devices wires or to eliminate the false alarms, the sensor board for monitoring of environmental parameters such as temperature, humidity, atmospheric pressure and different types of gases [23]" (figure 1).

III. METHODS - RESPONSE SURFACE METHODOLOGY IN SOFTWARE TOOLS OPTIMIZATION FOR MEDICAL REHABILITATION

The proposed methodology used in the work is based on Response Surface Methodology, described in [27]. This method is very often used in industry, in the optimization of technological processes [28], for example in the pharmaceutical industry and its application in medicine represents a novelty. In the paper "Response Surface Model Prediction of Deep Brain Stimulation Applied in Parkinson's Disease Tremor" [29], we proposed a model using RSM that choose the best target for DBS in order to reduce the Parkinson's tremor. "The results obtained with RSM guides us to find the best model for the kernel in which DBS will be made based on the input variables (tremor, frequency, and location amplitude). This mathematical model may be helpful for medical doctors and researchers. The proposed model shows other way of predicting and diagnosis the DBS results with a use of data mining techniques. The RSM proves to be the

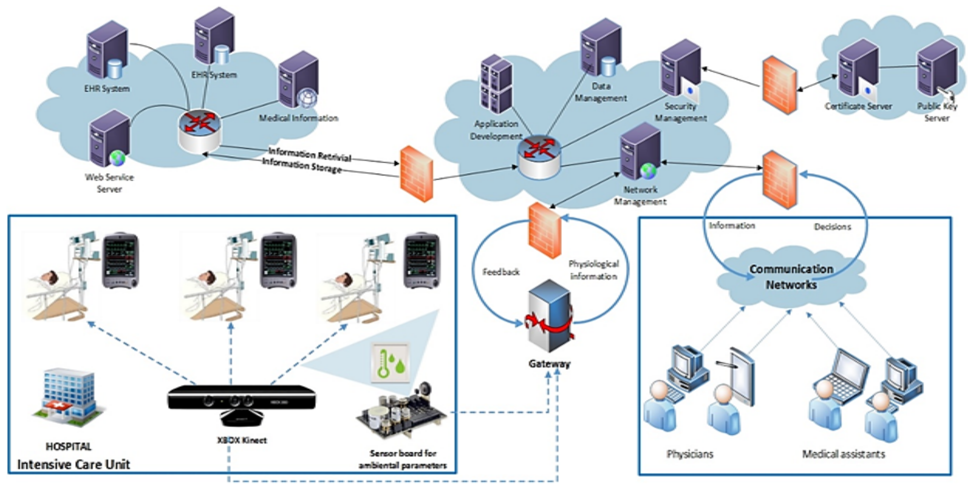

FIGURE 1. Healthcare system architecture for remote-monitoring in a smart environment [22].

effective tool for the development of a mathematical model for DBS target evaluation model. Further, this work can be extended to other neurological disorders'' [29]. The Response Surface Methodology (RSM) ''involves a combination of meta-modeling (i.e., regression) and sequential procedures (iterative optimization)'' [28].

In this paper, we present a medical recovery application implemented for upper limb rehabilitation, using a Kinect platform. The user's avatar pass through an orchard with apples and has to picks up red or green apples according to their level. Green apples are positioned at the base of trees, and red apples to the top. The game is 3D and during the game different angles of inclination of the neck, hand, shoulder, etc. are measured and a final score is generated. To find if the patient has progressed in his medical recovery, the final score should be increased. In order to find the score that a subject without a locomotor system disorder can achieve, we have optimized the game using mathematical modeling and canonical analysis by applying Response Surface Methodology (RSM) and Multiple Nonlinear Regression, using the Expert Design experimental software package (vers. 11). Compared to a polynomial model which allows the calculation of the response but does not give a slightly visible or intelligible representation of the surface of response, the method of response area allows finding the favorable value of a response (in our case the software optimization). Canonical analysis can reduce the estimated regression equation to a simpler form and interpret the resulting expression using geometric concepts. Areas that are functions of two variables can be easily represented in three-dimensional space, and the answer will be given by the value of the function.

Surfaces that depend on three or more variables can be projected into three-dimensional space, maintaining all variables constantly, with the exception of two of them whose variance is considered essential for the chosen model. Extreme points (maximum and minimum) of the surface is of particular technological interest because it shows the performance of the model chosen for process optimization.

The RSM, detailed in [29], is ''a set of mathematical and statistical techniques that explore the relationship between independent and variable-response variables in order to optimize the desired response of the investigated system to explore optimal operating conditions'' [29]. For many RSM studies, the central compound experiment and also the Taguchi method [30], are used.

The optimization process using the RSM, illustrated in figure 2, is a sequential procedure and is presented in [29]. For the optimization of our proposed algorithm, it was taken into account that the input variables were the avatars' inclination angles and the output variable were the scores obtained (the number of apples gathered). The results show that the best scores are obtained when the input angles are taken from the arms, column, and neck.

For our application of the RSM, it is necessary to use experimental projects, often using the central compound experiment: (1) a set of factorial experiments, (2) a set of central points and (3) a set of axial points. The center points have values equal to the median values used in the set of factorial experiments, while the set of axial points implies points outside the range of the points of the factorial experiments for all factors. As an alternative to the central compound experiment, the Box-Behnken experiment can be chosen.

In this paper, the response surface method was used in order to optimize the initial conditions to improve the functional properties of the medical recovery application. This experiment requires lower costs, but should only be used if it is assumed that the boundaries of the experiment are known. In the process of designing and analyzing the response surface experiments we used the: *Design-Expert* and *Statgraphics*.

RSM is useful for programs modeling and analysis in which a response of interest is influenced by several variables

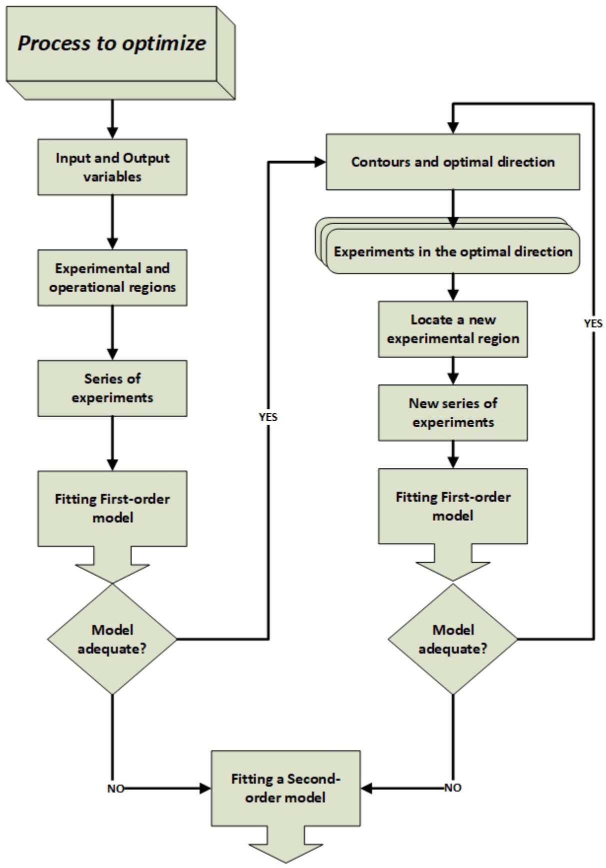

FIGURE 2. **The optimization process using the RSM.**

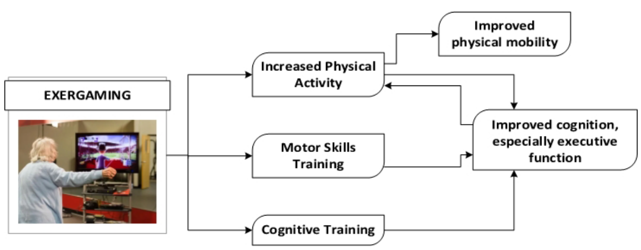

FIGURE 3. **A theoretical model of the mechanisms by which exergaming may benefit elderly's physical and cognitive health.**

and the objective is to optimize this response. For example, find the levels of spine degree (x_1) and neck degree (x_2) to maximize the score value (y) of the exergaming.

$$y = f(x_1, x_2) + \varepsilon \tag{1}$$

The response surface is:

$$\eta = E(y) = f(x_1, x_2) \tag{2}$$

The function f is unknown and approximate the true relationship between y and the independent variables by the lower-order polynomial model.

$$y = \beta_0 + \beta_1 x_1 + \Lambda + \beta_k x_k + \varepsilon \tag{3}$$

$$y = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum_{i=1}^{k} \beta_{ii} x_i^2 + \sum_{i<j}^{k} \beta_{ij} x_i x_j + \varepsilon \tag{4}$$

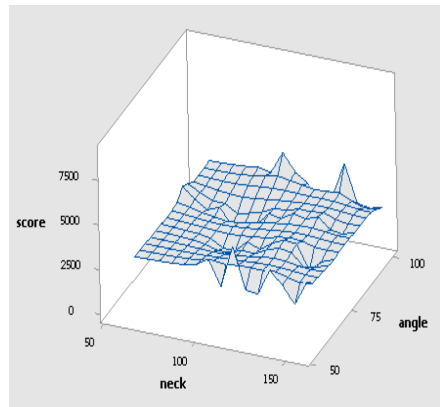

FIGURE 4. **The surface plot of score vs. angle and neck in the men's records.**

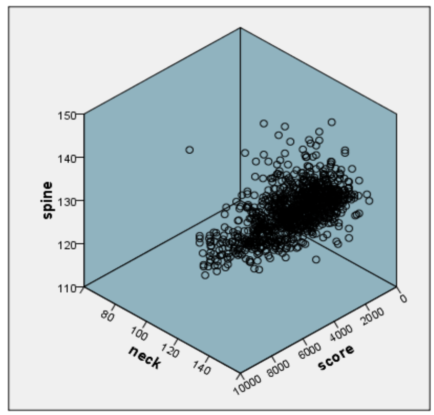

FIGURE 5. **The score distribution vs. spine and neck in the men's records.**

The Response Surface design includes:

(1) A sequential procedure;
(2) The objective is to lead the experimenter rapidly and efficiently along a path of improvement toward the general vicinity of the optimum;
(3) First-order model => Second-order model.

If we are closed to the optimum, the second-order model is used to approximate the response.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 x_2 + \beta_{11} x_1^2 + \beta_{22} x_2^2 + \varepsilon \tag{5}$$

Generally, the structure of the relationship between the response and the independent variables is unknown.

IV. MEASUREMENT SYSTEM ANALYSIS

Specialty studies have shown that stimulating cognitive abilities helps slow down disease progression, limiting the loss of neurological abilities and functions. The best result of Alzheimer's treatment by the serious gaming method was seen in patients with mild or moderate disease symptoms. Serious games are also called "training games". They are designed not for fun but for cognitive stimulation. It can be said that some games maybe included in the category of modern and useful therapeutic solutions. The study published

FIGURE 6. User interface: the diagram for the hypothesis test (capture from Minitab 18 software).

Statistics

		angle	lelbow	lshoulder	relbow	rshoulder	neck	spine	score
N	Valid	1013	1013	1013	1013	1013	1013	1013	1013
	Missing	0	0	0	0	0	0	0	0
Mean		79.08	150.65	92.40	151.12	91.03	122.96	125.89	2923.89
Std. Error of Mean		.454	.717	.938	.637	1.003	.290	.100	61.259
Median		85.00	157.00	94.00	157.00	93.00	124.00	125.00	2650.00
Mode		85	171	92	164	95	128	125	250
Std. Deviation		14.457	22.807	29.868	20.266	31.908	9.241	3.177	1949.717
Variance		209.004	520.179	892.096	410.705	1018.116	85.392	10.095	3801395.134
Skewness		-.184	-1.319	-.243	-1.408	-.134	-.671	1.213	.656
Std. Error of Skewness		.077	.077	.077	.077	.077	.077	.077	.077
Kurtosis		-.917	1.607	-.222	1.674	-.421	2.742	3.571	-.119
Std. Error of Kurtosis		.154	.154	.154	.154	.154	.154	.154	.154
Range		45	132	157	107	156	95	32	8900
Minimum		55	47	18	72	22	62	110	50
Maximum		100	179	175	179	178	157	142	8950
Sum		80105	152606	93602	153082	92218	124559	127530	2961900
Percentiles	25	70.00	139.00	74.00	143.00	70.50	118.00	124.00	1350.00
	50	85.00	157.00	94.00	157.00	93.00	124.00	125.00	2650.00
	75	85.00	168.00	112.00	165.00	114.00	129.00	127.00	4150.00

FIGURE 7. Frequencies for angles and for the final score (capture from data analysis tools).

by Psychological Science [31], a periodical journal of the Psychology Association, shows that some of the games, especially those based on action, can stimulate players' ability to coordinate visual information with better control of motor functions (figure 3). The utility of these benefits starts from the development of the skills to drive a car. But they are also useful for those who have motor coordination problems due to illness. Games are useful to those with multiple sclerosis, Parkinson's, balance-related disorders and more.

To implement mathematical models to optimize the recovery software, we used the DOE Expert Design Software Package (vers. 11), Minitab 18, and for descriptive statistics, we used IBM SPSS (vers. 25). The data acquired by the developed software contains the following information and variables: *sessions_ID, red_apple, gree_apple, timeamp, body_parts_ID, angle, lelbow, lsholder, relbow, rshoulder, neck, spine and score*.

The first stage is the experimental part that was performed to extract the dataset. The next step is the modeling of the

		angle	lelbow	lshoulder	relbow	rshoulder	neck	spine	score
angle	Pearson Correlation	1	.045	.324	.040	.191	-.186	.004	-.058
	Bayes Factor		14.619	.000	17.857	.000	.000	39.630	7.286
	N	1013	1013	1013	1013	1013	1013	1013	1013
lelbow	Pearson Correlation	.045	1	-.007	.273	-.026	-.118	-.028	-.060
	Bayes Factor	14.619		38.949	.000	28.024	.033	27.188	6.349
	N	1013	1013	1013	1013	1013	1013	1013	1013
lshoulder	Pearson Correlation	.324	-.007	1	-.042	-.227	.206	.042	-.085
	Bayes Factor	.000	38.949		16.546	.000	.000	16.331	1.032
	N	1013	1013	1013	1013	1013	1013	1013	1013
relbow	Pearson Correlation	.040	.273	-.042	1	.001	-.347	-.043	-.021
	Bayes Factor	17.857	.000	16.546		39.923	.000	16.002	31.786
	N	1013	1013	1013	1013	1013	1013	1013	1013
rshoulder	Pearson Correlation	.191	-.026	-.227	.001	1	-.542	-.163	-.054
	Bayes Factor	.000	28.024	.000	39.923		.000	.000	9.009
	N	1013	1013	1013	1013	1013	1013	1013	1013
neck	Pearson Correlation	-.186	-.118	.206	-.347	-.542	1	.079	.053
	Bayes Factor	.000	.033	.000	.000	.000		1.636	9.696
	N	1013	1013	1013	1013	1013	1013	1013	1013
spine	Pearson Correlation	.004	-.028	.042	-.043	-.163	.079	1	-.080
	Bayes Factor	39.630	27.188	16.331	16.002	.000	1.636		1.601
	N	1013	1013	1013	1013	1013	1013	1013	1013
score	Pearson Correlation	-.058	-.060	-.085	-.021	-.054	.053	-.080	1
	Bayes Factor	7.286	6.349	1.032	31.786	9.009	9.696	1.601	
	N	1013	1013	1013	1013	1013	1013	1013	1013

FIGURE 8. Bayes Factor inference on pairwise correlations.

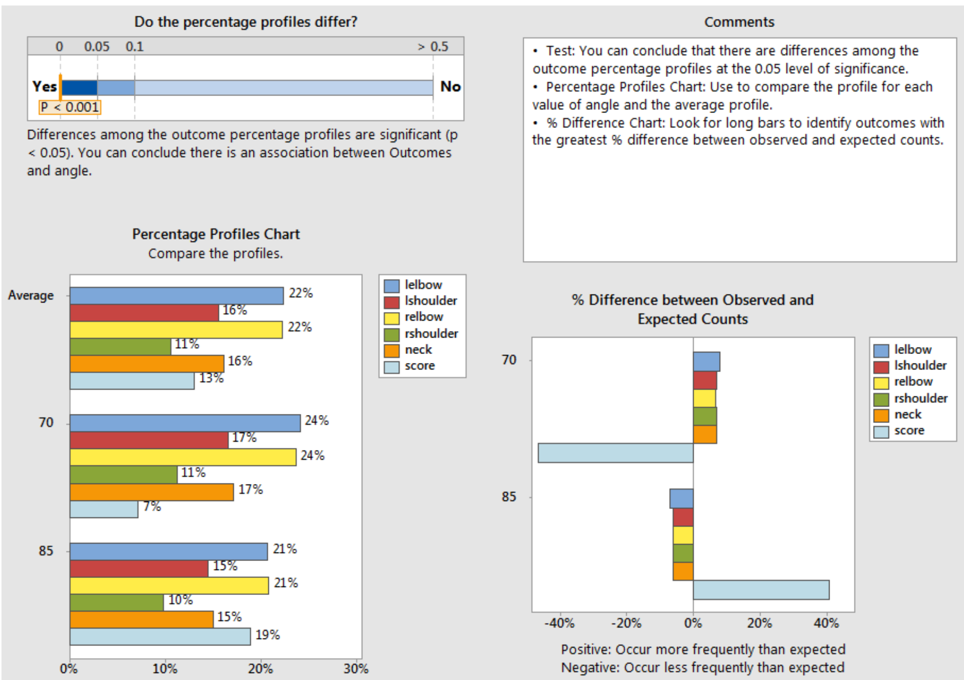

FIGURE 9. Chi-Square test for association: outcomes by angle.

score obtained by healthy subjects from the point of view of the locomotor apparatus and without neuro-muscular disorders. This information can be used for further comparisons, clustering, and classification in order to identify certain diseases, including neurodegenerative diseases. The next stage presents the model prediction corrections that were evaluated using several statistical indicators, such as the determination coefficient and the square square error (RMSE). The variance analysis (ANOVA) on RSM was used to check any significant lack of matching [31]. In the final stage, we aim to extrapolate the developed models and the RSM models will be evaluated for new data sets.

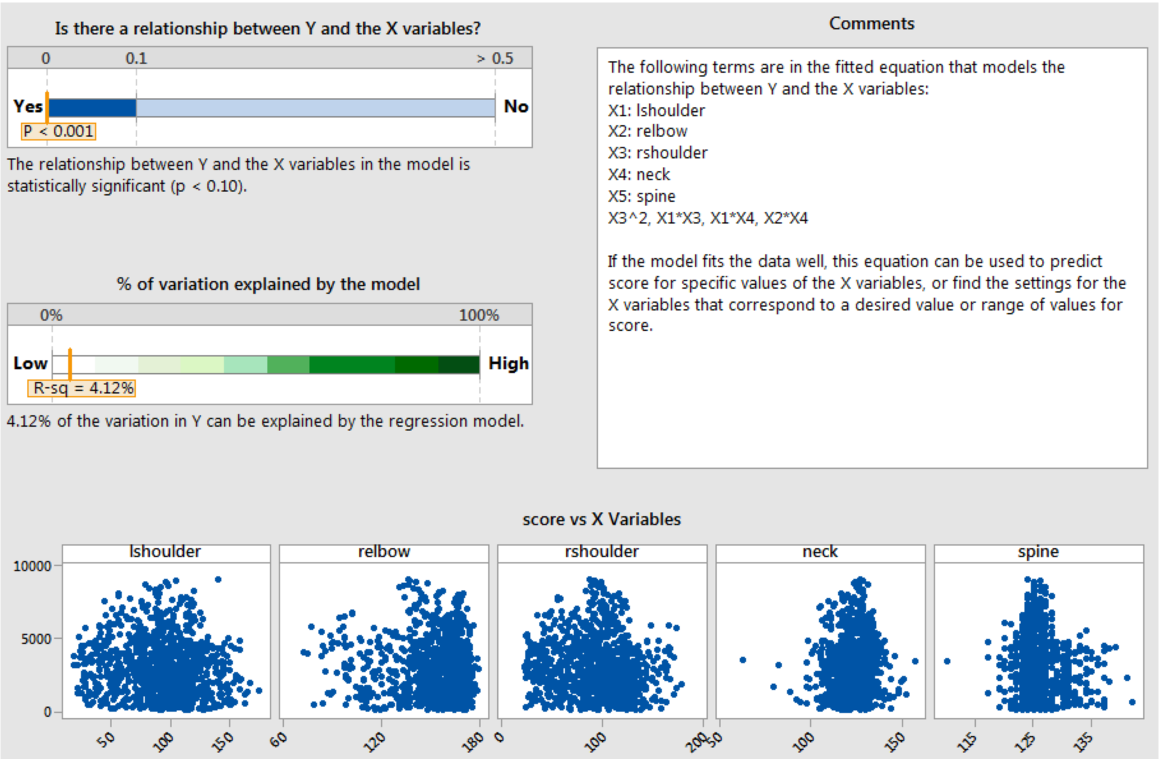

FIGURE 10. **Multiple regression for score – summary report.**

V. EXPERIMENTAL RESULTS AND DISCUSSIONS

In the first step, data types were defined and the basic Graphical Summary statistics were made. Then we used statistical elements appropriate to large datasets, such as *Descriptive statistics, Inferential statistics, Normal distribution*. Thus, the links between the variables and their influence on the final outcome of the algorithm have been identified. To test hypotheses and to find confidence intervals, Minitab software provides tools such as: *Testing the Null Hypothesis and the Alternative Hypothesis (H0 and H1), Alpha Calculation, P-Value, Finding Type I and II Errors, 1 -Sample t-Test, 2 Variances Test, 2-Sample t-Test, Paired t-Test, 1 Proportion Test, 2 Proportions Test, Chi-Square Test.*

In tables, 1 is presented the datasets for men, with 1012 records, and women, with 1062 records. In figures 4 and 5 are the scores obtained by the men participating in the study, depending on the angles of the spine and neck.

After performing the experiments and obtaining the mathematical model associated with the factorial experiments, some statistical hypothesis checks are required (figure 6):

- Verifying the homogeneity of the dispersions obtained at the repetition of the experiments, which is achieved with the Cochran criteria;
- Checking the degree of statistical significance of the regression coefficients, with the Student criterion;
- Check the adequacy degree of the mathematical model using the Fisher criterion.

If the Fisher criterion shows that the linear mathematical model is inadequate, then the factor variation intervals (in view of a new experiment) are reduced, or a second-order factorial experimental program is built for a series of new experiments. Figure 7 presents the frequencies for angles and for the final score.

The square mean deviation parameter can also be expressed in a relative form, the case is called the Pearson variation coefficient, and is denoted by V_x. Pearson's variance coefficient calculated for two or more series can be used in comparative estimates of the degree of the calculated mean value (figure 8).

Because the degree of the mean value is inversely proportional to Pearson's variance coefficient, it can be stated in several series that the mean value of that series for which V_x is lower and so more representative. In conclusion, it should be noted that the mean square deviation parameter in absolute form σ_x and in relative form V_x are fundamental indicators used to measure the variance of a variable.

Statistical dependence of the study factors necks and spine, as well as a separate influence but and conjugated of them on the score are set with the verification of statistical hypotheses of independence, using tests of type *Chi-square and Fisher*, based on observation data (values measured from experiments) grouped in figure 9. We used the software package *Expert design* which determines the calculated values and test tables corresponding to *Chi-square and Fisher*. On the basis of these assumptions of independence, the

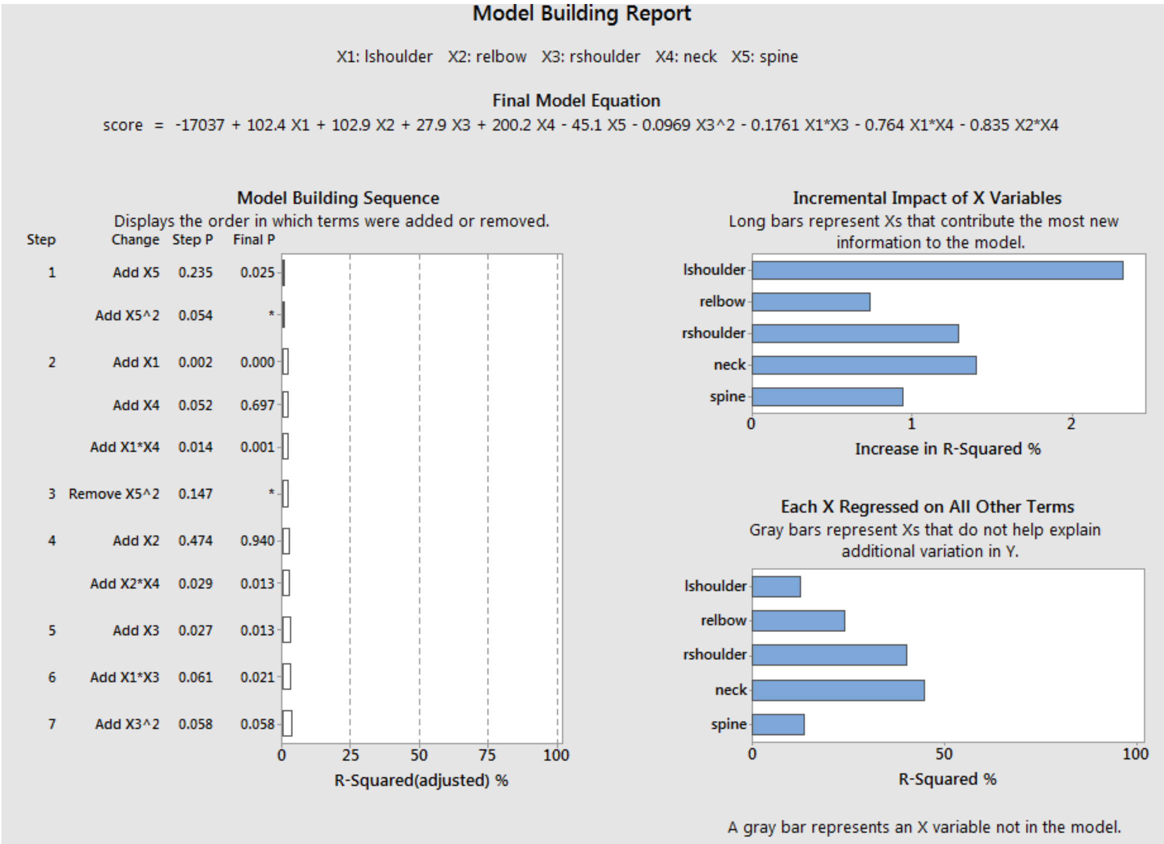

FIGURE 11. Multiple regression for score – model building report.

TABLE 1. Statistics for men and women.

Variable	Total Count	N	N*	CumN	Percent	CumPct	Mean	SE Mean	TrMean	StDev
Red_apple	1013	1013	0	1013	100	100	0.5656	0.0156	0.5730	0.4959
Green_apple	1013	1013	0	1013	100	100	0.4344	0.0156	0.4270	0.4959
Body_parts_ID	1013	1013	0	1013	100	100	8.1027	0.0776	8.0582	2.4694
Angle	1013	1013	0	1013	100	100	79.077	0.454	79.254	14.457
Left elbow	1013	1013	0	1013	100	100	150.65	0.717	152.64	22.81
Left shoulder	1013	1013	0	1013	100	100	92.401	0.938	92.738	29.868
Right elbow	1013	1013	0	1013	100	100	151.12	0.637	153.01	20.27
Right shoulder	1013	1013	0	1013	100	100	91.03	1.00	91.01	31.91
Neck	1013	1013	0	1013	100	100	122.96	0.290	123.20	9.24
Spine	1013	1013	0	1013	100	100	125.89	0.0998	125.69	3.18
Score	1013	1013	0	1013	100	100	2923.9	61.3	2820.0	1949.7

two variables (study factors of angles) and, both individual and simultaneous influences variables on the final score, can be accepted with the assured risk, respectively rejected with precision ($p = 0.95$ in general).

The regression function obtained by the minimum square's method may be a more or less efficient adjustment of the cloud point distribution (figures 10 and 11). The more cloud points are closer to the regression line, the better the adjustment. To measure it numerically, we appeal to variance analysis (ANOVA - Analysis of Variance).

A series of tests were designed to carefully evaluate the response (output of the model) as a function of variations of the input variables (*angle, lelbow, lsholder, relbow, rshoulder, neck, spine*- see table 1) (figure 12).

The advantage of RSM is that it uses a minimal amount of experimental data to develop a model for obtaining a model score (for subjects without neuromuscular damage) with a high level of precision. The RSM shape the effect of the various variables of the input process, both on the main effects and on the interaction, on the output variable of the process,

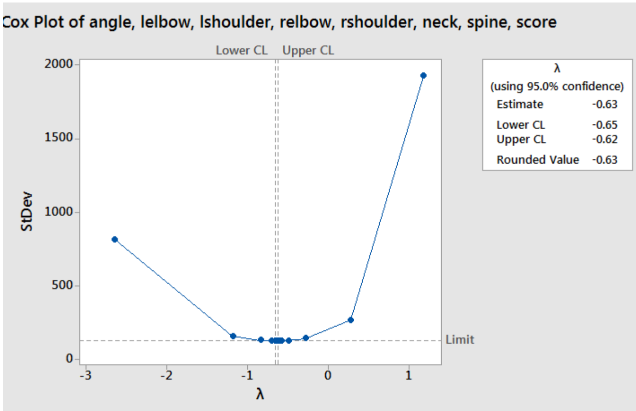

FIGURE 12. The plot of angle, left elbow, left shoulder, right elbow, right shoulder, neck, spine, and score.

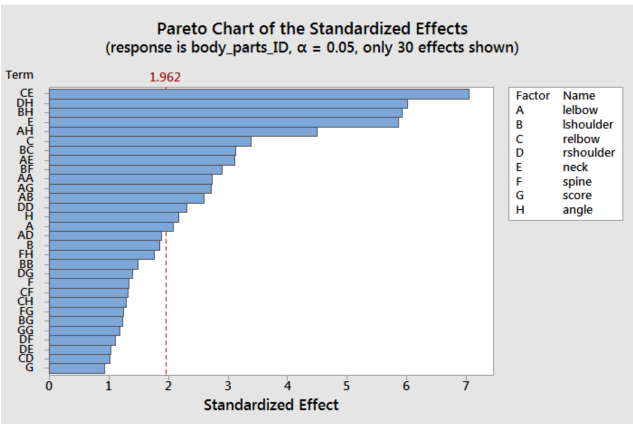

FIGURE 13. Pareto chart of the standardized effects.

in our case the score for subsequent comparisons on groups of neuro-muscular disorders. To optimize the exergaming for rehabilitation we used this methodology depending on input variables and patient score. In this case, we studied the influence of two variables, the neck, and spine, on several indicators: *angle, lelbow, lsholder, relbow, rshoulder*, acting in the response function, meaning the final score obtained by the patient (figure 13).

In our study, a specific RSM model, called CCD, was used to determine the experimental conditions because the complexity required for the software model was not known for the exact predictions. This design allows the use of a wider range of conditions [32], [33], compared to other RSM techniques [31]. An RSM experimental array based on three factors considered was generated using the *Design Expert*software and *Minitab*.

The project included 30 rounds, consisting of 10 axial points, 15 factorial points, and 10 central points. The score function of the resulting solution was then modeled using a square equation:

$$z = a + bx + cy + dx^2 + ey^2 + fxy \tag{6}$$

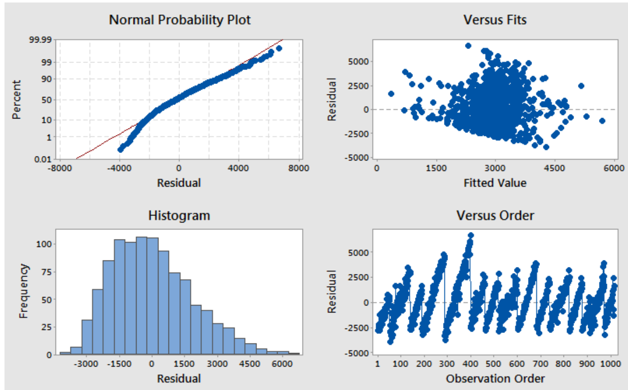

FIGURE 14. The residual plots for score.

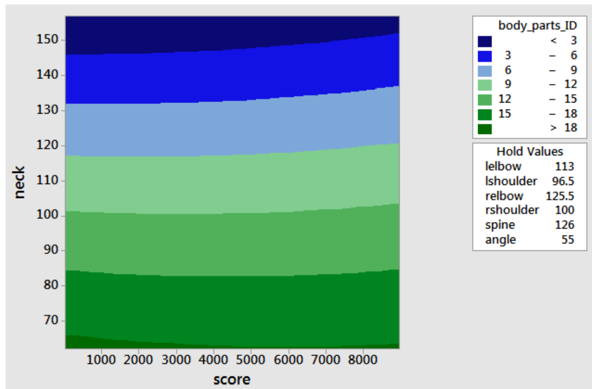

FIGURE 15. The contour plot of body parts vs. neck, score.

In order to check our residuals (our error terms) to see if our equation works well for all predicted values or if our equation works really well at predicting low-quality ratings but works poorly for predicting high-quality ratings. There are all sorts of different residual analyses that could be done. Two of them are particularly helpful – Histogram and Residual vs. fits – contained on the ‘Four in one’ Graph. The encoded design variables have been used to perform all analyzes and the model created for a CCD. The numerical results will be different and often it will be more difficult to interpret the results compared to the coded unit analysis. Moreover, in the coded variable analysis, the comparison of the effect of changing each design factor within a single unit interval can be easily achieved by checking the magnitude of the coefficients of the obtained model [31]. In this study, each independent parameter was encoded in five levels (−1,5, −1, 0, 1 and 1,5), according to equation:

$$x_i = (x_i - x_0)/\Delta x \tag{7}$$

where x_0 to x_i are the selected parameters at the center point and Δ_X is the step change.

The figures 14 and 15 illustrate a plot of the values predicted by the RSM model according to the measured experimental data. Choosing this mathematical model of the response function offers the advantage that it allows easy

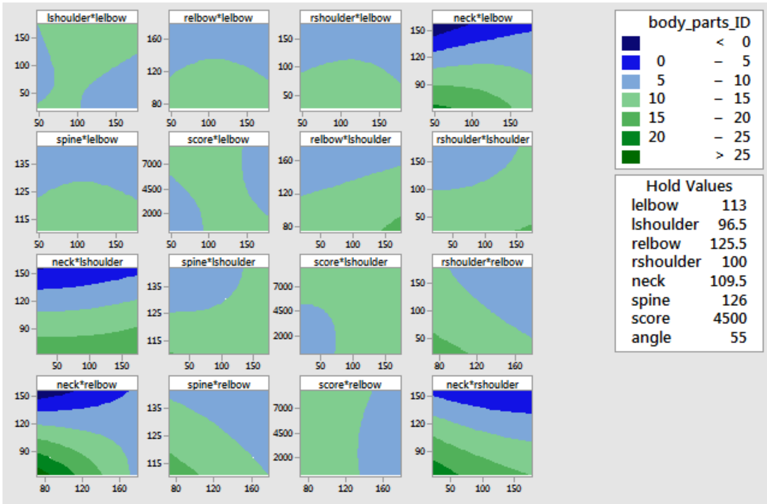

FIGURE 16. The Contour Plots of body parts.

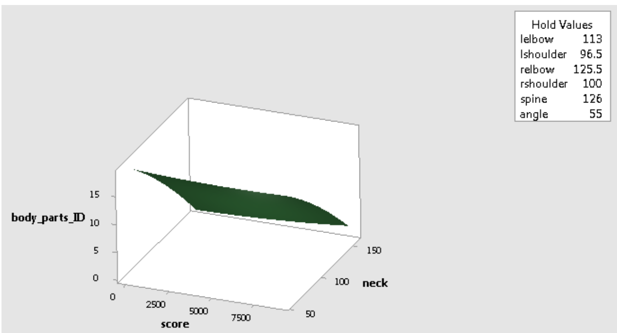

FIGURE 17. The surface plot of body parts vs. neck, score.

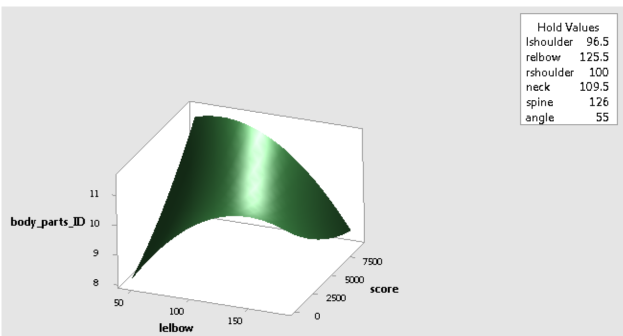

FIGURE 18. The surface plot of body parts vs. score, left elbow.

interpretation of the individual influence of each component, as well as the conjugate influence of the two variables on the response function (figures 16 to 18). The Chi-square apply for high volume selections (number of values of observation of the factors whose independence/dependency is investigated: $N > 1500$). If $1000 < N < 15400$, and the contingency table does not contain expected counts with values less than 5, then the application Chi-square is also valid. If $N < 1000$ and the contingency table contains no more than 20% of the expected count with the values between 1 and 5, then the Fisher test is preferable to Chi-square test. The *df value* (free degree number) represents the number of degrees of freedom in relation to which it is determined to test tab values.

VI. CONCLUSIONS

The study presented in this paper has proved that the Response Surface Methodology (RSM) is a successful tool in the prediction of the variable score. In order to evaluate the prediction capacity of the developed models, several statistical indicators were used. A CCD project, as a specific design of RSM, was chosen to determine the experimental conditions. In terms of prediction of the test score in the design intervals, a high coefficient (R2) of 99.2 percent was obtained for the RSM model, demonstrating a great precision of the model. In conclusion, the Response Surface Methodology can be a valuable solution for some types of problems that, generally, fall into three categories: (1) Mapping a Response Surface over a Particular Region of Interest; (2) Optimization of the Response and (3) Selection of Operating Conditions to Achieve Specifications or Customer Requirements. In this work, a medical recovery game that uses a Kinect platform is presented. The exergaming is designed and implemented for upper limb rehabilitation and can be used in therapy-based game for older adults with brain disorders.

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