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The Haptic Aplication in Environment of Virtual Reality for Learning

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Abstract

In this research, haptic applications are designed which generate sensory response in virtual reality environment that are widely used in computer engineering. Force feedback haptic applications are developed for education in virtual reality environment which contain related software and hardware devices with regard to algorithms stages including gravitational force. The topic of inter planets gravitational force is designed by using OpenGL based OpenHaptics libraries on Visual Studio 2010 C++ software platform according to planned algorithms stages. Mathematical features of globes are coded according to determinated algorithms stages in application development process including software engineering. Haptic application environment is established and based on human-machine interaction comprised of hardware and software devices by integrating haptic devices, display units, computer and coded software devices. In research, while 106 students are taught by using designed haptic application in virtual reality environment, 109 students are taught by traditional teaching medhods in class on same physic topics throughout 15 days. Two surveys are conducted for students in different groups separately after lectures, and they are examined. Efficiency of learning environments is researched by assessing obtained data from results of surveys and exam with ZeroX and J48 algorithms in data mining program named weka which performs machine learning.

Keywords: Haptic Device, Virtual Reality, Human-Mechine Intraction

1. Introduction

Haptic means sense of touch (Salisbury, 1999). Haptic devices were used for storing chemical and nuclear substances in 1960s. It became a new research area in information technologies by means of appearing PHANTOM as a personel haptic interface mechanism in 1993, and it has been developed by additional researches until today(Salisbury & Srinivasan, 1977).

Force Feedback or Tactile Feedback System means feedback of areas where the transmitted force by haptic devices with interaction of virtual objects is felt immediately by proprioceptive receptors in tendonsand muscles(Frey, Hoogen, Burgkart & Riener, 2006). The system stimulates administrative areas where applied force from anenvironment of virtual stimulent to user is transmitted as a push back,and it involves haptic devices and applications which include tactile and force feedback sensory structures simultaneously(Aggarwal & Kirchner, 2014). There are also studies which search haptic image rendering and its stages (like collusion management, force feedback, modelling, dynamic simulations) (Kim, Lee, Kim, Kim & Ryu, 2009; Frisoli, Bergamasco & Ruffaldi, 2008; Wang, Giannopoulos, Slater, Peer & Buss, 2011).Haptic supported virtual reality environments rush into our daily lives as a result of simultaneous developments in software and hardware in computer sciences. Designed 3-dimension (3D) pictures and animations, and head-mounted display(HMD) and HD for human-computer interaction accelerate process of entertainment and education in virtual reality environment (VRE)(Kayabaşı, 2005).

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VRE is useful in designing and education (Magnusson, Tollmar, Brewster, Sarjakoski & Roselier, 2009),it can be expanded and interactive(Tzovaras, Moustakas, Nikolakis & Strintzis, 2007), and it is applicable(Talaba & Antonya, 2014). VRE attracts many researchers thanks to its efficient control, simultaneous feedback, performance measurement and decreased hazards (Seidel & Chatelier, 1997).

Learning information in education is only possible in fluent learning platforms which include multible sensory medhods(Santos & Carvalho, 2013), they develop by means of hands and eyes applications, and they are based on surveys and experiments(Dionisio, Henrich, Jakob, Rettig & Ziegler, 1997).VRE eases abstract notions(Bozkurt, 2008; Civelek, Ucar & Gokcol, 2012)and macro-micro dimensional objects(Subası & Boşdoğan, 2008) in that it includes experiment based visual and tactile applications compared to traditional class education which is weaker in terms of experience, survey and interaction. It is more incentive in terms of individual and collaborative education, improving and developing lessons contents(Civelek, Uçar, Ustunel & Aydın, 2014), and it is more adventegous than traditional education(Rose, Brooks & Attree, 2000).

VRE with haptic application induces to efficient practice of human perception system by using different senses in learning process effectively and simultaneously, and it increases retention and productivity of learning(Bingel, 2009). VRE with features of Tactile(Diego, Cox, Quinn, Newton, Banerjee & Woolfor, 2012), visual and kinesthetic(Pusch, Martin & Coquillart, 2009)is real-time interaction including human-machine interaction, and it provide opportunity for more meaningful learning (Karal & Reisoğlu, 2009).

1.1 VRE Application Fields

Haptic Technologies are used in medical education,surgical operations, neurosurgery education (Lemore, Banerjee, Luciano, Neckrysh & Charbel, 2007), epidural needle practices(Jiang, Gao, Chen & Sun, 2013), Telepresence operations(Ueberle, Esen & Peer, 2014).It is also used dentistry and sensory production(Wang, 2013). There are various practices in physic such as hoist, friction, mass, volume, gravitational force etc.(Willianms, Chen, & Seaton, 2000; Williams, He, Franklin & Wang, 2004), in biology such as molecular features (Subası & Boşdoğan, 2008), in chemistry for forming molecule(Trindade, Fiolhais, Gil & Teixeira, 1999; Haag & Reiher, 2013), in private education for visually impaired (Plimmer, Reid & Blagojevic, 2011), in geometry(Moustakas, Nikolakis, Tzovaras & Strintzis, 2005).

2 Medhod and Data

Haptic application based virtual reality environment is formed for improving students' learning abilities and learning environments. Globes are modelled by using C++ sofware with OpenHaptics toolkit, and algorithms are coded for transfering the force between sun and planets. While modelling law of gravity, mass of planets (m), gravitational constant (G),orbital velocity (v), orbital radius (r) and orbital period (*T*) are formulated and coded belowwith orbit, velocity and gravitational force(F) of planets(Önengüt, 2009);

1.

2.

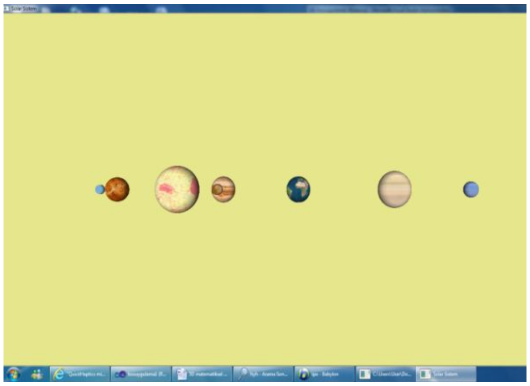

Figure 1 The Haptic Aplication in Virtual Reality environment

Essive situations are coded for safe work of device while it interacts with virtual objects inside haptic environment and interface provided in figure 1:

```
if(mesafe < Yaricap*2.0)
   { vekFark.normalize();
     kuvvetVek = G * vekFark * mesafe / ( Yaricap *
static int i=0; }
else { kuvvetVek = G * vekFark / (mesafe*mesafe);}
```

In coding,laws of force can be changedfor spattering with '*İf (mesafe < Yaricap*2.0)* condition', and two objects pull each other until they coincide. Quadrate of gravitational force is applied inversely proportional to distance usingthe code line in *else*condition.Received force from Phantom omni is inversely proportional to quadrate of distance between objects.

```
for(int i=0;i<3;i++)
   { if(kuvvetVek[i]>nominalMaxDevamEdebilirKuvvet)
        kuvvetVek[i] = nominalMaxDevamEdebilirKuvvet;
if(kuvvetVek[i]<-nominalMaxDevamEdebilirKuvvet)
        kuvvetVek[i] = -nominalMaxDevamEdebilirKuvvet;}
         return kuvvetVek;
```

Forces are calculated by using*'for(int i=0;i<3;i++)'* formula.If maximum confidence interval of haptic device is exceeded, the value of force vectoris changed. Hence, haptic device is ensured not to work apart from this confidence interval.

Haptic application based virtual reality environment is designed in order to provide communication of computer, modelled virtual environment, display units and haptic device with one another after regulations above during software development process.Individual interaction of students with applications and virtual environment by means of teaching lessons to themby teachers is provided. While randomly chosen 109 students are taught about gravitational force of masses in class by traditional medhods for a month period, different 106 students are taught with the same topics and period in haptic application based virtual reality environment.

Students are examined by 10 questions after teaching period. While students who get scores between 0 and 44 are declared unsuccessful, those who get scores between 45 and 100 are accepted successful. Data collection is made by using surveys.Survey questions are generated by previous results of searching resources in the same area. Question are prepared carefully to be apparent, simple and relevant for purpose of study.

2.1 Data Analysis Medhod

The developer version of Weka 3.7.4 program is preferred to analyse data from research in that it uses Machine Learning (Sitar-Taut & Sitar-Taut, 2010) which is more suitable for new situations in order to get informations previous practices and to develop new learning tecniques of computers with bulks of data analysis (Witten Frank & Hall, 2011).

J48 renewable algorithm based on Gain Theoryis used for evaluating data. J48algorithm gives outputs of membership function sets and decision tree by dividing and chosing releated samples according to IF-THEN rules(Mollazade, Ahmadi, Omid & Alimardani, 2008). Decision trees have features of graphical presentation with high accuracy rates and efficient decision making charasteristics which eases to understand results of data collection(Sitar-Taut, Zdrenghea, Pop & Sitar-Taut, 2009; Sıtar-Tăut &Sıtar-Tăut, 2010). They generate a classification tree as result of usage of data/samples based on divide and conquerstrategy in education(Safavian & Landgrebe, 1991; Pooja, Jayanth & Shivaprakash, 2011). The constructed decision tree from top to down is started by chosing the best root variable and dividing experimentals. Attributes are placed as nodal point, and leaveswhich indicate class labels are generated(Li, Fu & Fahey, 2009). J48 prunes weak leaves fo classify data simply,and transforms to understandable rules(Hu & Mojsilovic, 2007).

Kappa Value(K) indicates magnitude of concurence between surveys. It is a measurement that changes between -1and 1 (Viera, & Garrett, 2005). If it approaches 1, rate of concurence. The gap between 0.41 and 0.60 is a admissible value.

F-Measurement(F) is harmonic mean of Precision ve recall for data classification (Han & Kamber, 2006). İf the value approaches to 1, relevant class is more successful for learning algorithm.

3 Findings

While 108 (%50.2) of 215 samples are classified as true with ZeroR primitive algorithm, 107 (%49.8) of them are classified as false in Table 1 by means of evaluating with Weka. Kappa Statistic value is 0. While 169 (%78.6) of 215 samples are classified as true with J48 classification algorithm, 46 (%21.4) of them are classified as false. Kappa Statistic value is 0.572.

Table1 Confusion Matrix (ZeroR and J48)

ZeroR Confusion Matrix			J48 Confusion Matrix		
a	b	<--classified as	a	b	<-- classified as
108	0	a = P	86	22	a = P
107	0	b = F	24	83	b = F

That true classification number of J48 algortihm is bigger than true classification number of ZeroR algorithm indicates that 48 algortihm makes learning realize. If J48 kappa Statistic value(0.572) is between 0.41 and 0.60 according to Silman Table 2, the success of learning of J48 algorithm is moderate and acceptable(Brennan & Silman, 1996; Demir, 2006).

Table2 Results of Analysing Survey Data with WEKA Program

Type	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area
ZeroR	0.502	0.502	0.252	0.502	0.336	0
J48	0.786	0.214	0.786	0.786	0.786	0.824

It is seen that *F(J48) > F(ZeroR)* in Table. That F-Measure value of J48 algorithm is bigger and close to 1 indicates that it is more successful for making learning realize. As a result of analysing survey data with WEKA program, J48 algorithm makes the best learning in Medhod. The decision tree in the picture below is obtained according to learning style which is realized by J48 algorithm in WEKA program.

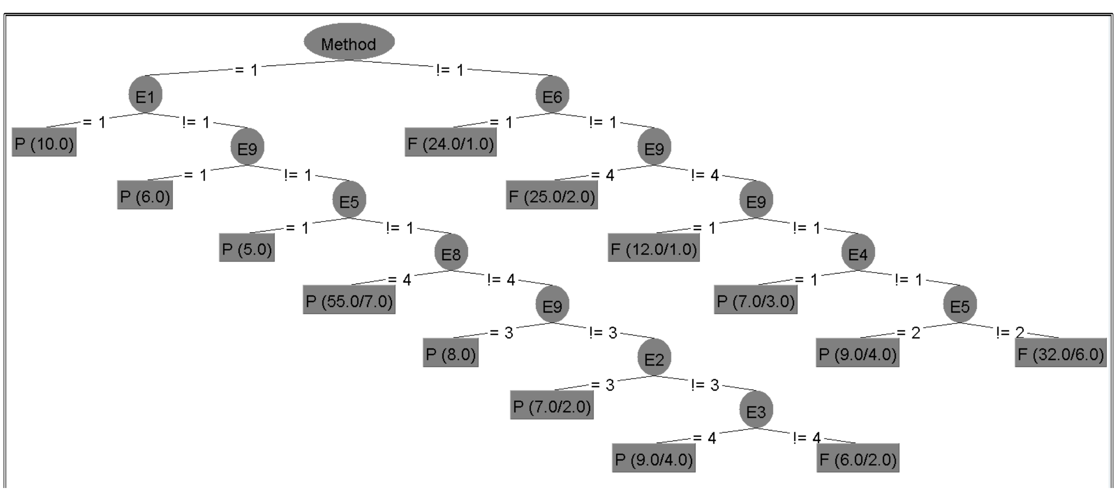

Figure 2 J48 Decision Tree

The obtained results from students who are taught by WEKA program with J48 algorithm in haptic application based virtual reality environment are below according to decision tree:
E1- Can environments present suitable contents for your lesson requirements?
10 students prefer to No, 79 students prefer to little/moderate/welllevel;
E*9-Do environments make topics become concrete in your mind?*
6 students prefer to No, 73students prefer to little/moderate/well level;
E*5-Do you perceive gravitational force topic from lecturing in environments?*
5 students prefer to No, 68 students prefer to little/moderate/well level;
E*8-Does the medhod of lecturing in environments make you appear easily in lessons during lectures?*
20 students prefer tolittle/moderate/ level, 48 students prefer to well level, sayı yok No/little/moderate level;
E*9-Do environments make lectured topics become concrete in your minds?*
12 students prefer little/well level;
E*2-Do environments enable to present substantial lesson content?*
5 students prefer to moderate level, 7students prefer to well level;
E*3- Do you find samples in environmets realistic, workable and practical?*
5 students prefer to well level successful,
E*3- Do you find samples in environmets realistic, workable and practical?*
4 students find them unsuccessful in no/little/moderate level
The obtained results from students who are taught by WEKA program with J48 algorithm in traditional teaching medhod are below according to decision tree:
E6- Can you touch objects like earth in environments?
23 students prefer to no, 67students prefer to little/moderate/well level;
E9- Do environments make topics become concrete in your mind?
11 students prefer ton no, 33 students little/moderate level, 23 students prefer to well level;
E4-Do environmets enable you to see materials that can not be carried to class?
30 students prefer to little/moderate/well level;
E5- Do you perceive gravitational force topic from lecturing in environments?
26 students become unsuccessful in no/moderate/well level.
E4- Do environmets enable you to see materials that can not be carried to class?
4 student prefer to no
E5- Do you perceive gravitational force topic from lecturing in environments?
5students become successful in little level.

4 Discussion and Result

A mathematical virtual modelling of gravitational force between planets which is a topic in syllabus is done in order to design haptic application based virtual reality environment in our study. The steps of algorithm for modelling are performed, and orbits of planet are coded according to mathematical relations which refer to velocity and gravitational force between globes.Required essives within confidental interval are coded in order not to damaged haptic device from force which is transmitted to arm during interaction. Then, communication between units (such as HD and HDM) and virtual objects which are designed with software in application interface. Interaction between students and ready to use haptic application based virtual reality environment in the grip of teachers is provided, and lecturing topic about inter planets and applications are performed. The same topic is taught to different students in traditional medhods, The students who are taught in different educational environments are conducted a survey after teaching period, and productivity of the environments are analysed. Obtained data from surveys are evaluted by using ZeroR and J48 classification algorithms in WEKA program which performs machine learning. They are divided 10 layers by using ‘cross-validation’ choice in J48 classification algorithm.While 1 piece is used for testing modelling, and n-1 pieces are used for iteration.

Learning with haptic application based virtual reality environment(HABVR) are more successful than learning in traditional medhods. The reason behind more success of HABVR is that it enriches lesson contents, and it is more practical and workable.This result is parallel to findings of (Civelek, Ucar & Gokcol, 2012; Civelek, Uçar, Ustunel & Aydın, 2014) in his study that emphasizes HABVR enriches lesson contents.

Because it enables *materials that can not be carried to class*, then it provides gravitational force between globes to be received by arms during virtual interaction and it gives sense of touch to virtual globes during contact, it can be preferable. Interaction between virtual objects and HD-display units in learning environments, then usage of different senses in learning environments simultaneously andtactile, visual and kinesthetic features of it increases learning productivity. These findings are supported by previos studies (Bingel, 2009; Diego, Cox, Quinn, Newton, Banerjee & Woolfor, 2012; Pusch, Martin & Coquillart, 2009). HABVR which gives an opportunity of real-time and meaningful human-machine interaction, also provides to become concrete of topics in minds and to receive concepts better such as gravitational force, mass and radius. These findings are the same in previous studies (Santos & Carvalho, 2013; Karal & Reisoğlu, 2009).

HABVR provides instant and useful feedbacks during interaction, design and learning processes. This finding is also supported by previous studies(Magnusson, Tollmar, Brewster, Sarjakoski & Roselier, 2009; Tzovaras, Moustakas, Nikolakis & Strintzis, 2007; Seidel & Chatelier, 1997). The force that are generated by crash between virtual objects and cursor that represents haptic device during HABVR interaction, is transmitted to muscles and tendons (Frey, Hoogen, Burgkart & Riener, 2006; Aggarwal & Kirchner, 2014; Kim, Lee, Kim, Kim & Ryu, 2009; Frisoli, Bergamasco & Ruffaldi, 2008; Wang, Giannopoulos, Slater, Peer & Buss, 2011).It embodies efficiently virtual objects ans presented topics with image processing.

Previous studies indicate that HABVR increases learning productivity in education like many fields. This study puts forth that designing a practical, force interaction, workable and realistic HABVR which enriches lesson contents, presents force interaction and concretes them in minds, and using it as learning environment will raise success. In addition to them, it realizes experiments which require macro-micro and expensive applications that is difficult to perform because of lack of materials and especially can not be carried to laboratory environment. Designing HABVR and codification these topics according to mathematical relations will have an important effect on embodying intangible concepts.

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