The phenomena of impact seen through an experiential application

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Abstract

The purpose of this paper is to present how by the interaction of a particular simulation we can deduce the phenomena that govern the motion of some elementary particles subject to elastic collisions. The interactive application, that we will take into account, was created using the graphics and the calculation capabilities of the software Mathematica (version 6.0).

1 Introduction

Learning is a process by which you can acquire new knowledge and on which different aspects can have an impact:

- Individual cognitive strategies, learning styles, individual and collective experiences;
- Phenomena of the surrounding environment, information and stimuli from the external reality;
- Models, formalisms, theories and dynamics of educational agencies;
- Media and processes that regulate the exchange of information.

Learning is a dynamic structure which follows non-linear and non-sequential paths. In particular, the constructivist theory is based on the assumption that, through reflections on our experiences, we can build the knowledge of the world we live in.

The deduction of the different phenomena that govern the laws of motion, adheres to a particular type of learning, inductive-experiential learning (Brosseau, 1997), whose characteristics will be described in the first part of this work. The typical scenario is everyday life, in which each individual learns through direct experience, interacting with the different aspects of reality and observing the effects of his/her actions.

The problems of impact are represented in many fields of physics, chemistry, biology, but also in applied sciences or engineering. Because of its wideness, the Field Of View's goal is to study the phenomena of impact, with specific reference to elastic collisions.

2 Inductive-experiential learning

Experiential learning is different from symbolic-reconstructive learning since the first is direct while the second is mediated by words.

When you learn from words, in general, there is no direct experience of the reality of which you speak and the actions are performed directly.

Simulations are one of the most appropriate ways to implement experiential learning, where we learn by doing, manipulating objects and, perhaps, having fun (Rotondi, 2000). It is not easy to define exactly what is the meaning of simulation, since this term is often used in different contexts. In the learning context, this term refers to some educational methodologies which focus on the reproduction of virtual situations, things and people. In general, a simulation is a program that reproduces a model of a real or imaginary system.

This model is governed by mathematical laws and/or logical propositions and the user can interact with it by changing some parameters and observing the changes induced on the model.

3 The description of the scenario

The scenario of reference is a pool table. The choice is not trivial, but dictated by specific considerations, related to the possibility of being able to observe three different types of impact: the collision between the billard-cue and the ball, the collision between two balls and finally the collision between the ball and the edge of the pool table.

So, the user will have the opportunity to observe in sequence three different phenomena by manipulating specific parameters characterizing the system such as the mass of the balls, the ball position, the angle of impact between the rod and the sphere, the force by which the sphere hits the ball, etc.

For each defined set up, he/she will be able to check the corresponding evolution of the system hence answering to questions such as: which are the variables involved? What is the relationship between the variables? Are there quantities preserved and if there are, can we consider them the same for all three types of impact?

4 The front-end application

The developed application has been implemented using the graphics and calculation capabilities of the software Mathematica version 6.0. The combination of built-in procedures (Malchiodi, 2007) allowed us to create a tool graphically attractive, interactive and easy to use in order to process the different configurations defined by the user in real time. The case study of the application, as mentioned earlier, is a pool table with two balls placed on it.

The 3D functionality of the software has allowed the realization of a three-dimensional environment in which the user is able, by simply dragging the mouse, to define the view that is most congenial. The next figure shows the front-end of the application:

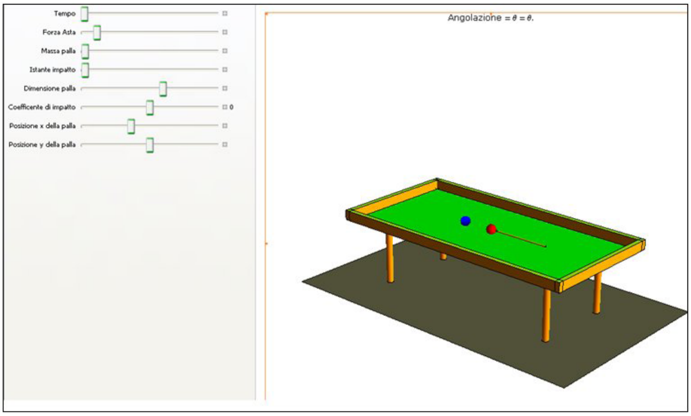

Fig. 1: front end of the application

As you can see in the picture, the application interface consists of two different sections. The first, of control, by which the user, through interaction with different sliders can change the set up of the system. In particular, he has the option in the configuration mode to change the mass of the spheres, their size, the force by which the pole crashes onto the red ball, the angle of impact and position of the blue sphere.

During the simulation, however, he/she is able to observe, for each simulation time, the correspondent value assumed by the free described parameters. Instead, the second section is purely graphical. In that panel all the realized graphic objects are shown, in our case the balls, the pole and the pool table. The latter is obtained as a combination of different decoupled elements for individual edges, feet, the support and the green cloth.

Completed the set up of the system and after choosing the ideal view, it is possible to observe the evolution of the balls on the pool table according to the selected configuration. Repeating the simulations, by changing the free parameters of the system, the user can understand what are the variables involved and can deduct the relationships that govern them. Furthermore, observing the three different types of collision, he may understand if there are quantities preserved and if they are the same for all three observed collisions.

4.1 Impact between billiard-cue and ball

In this phase the user wants to discover the dynamic properties of elastic impact through inductive experiential learning based on the analysis of the motion of a sphere caused by a stress pulse applied with a pool. Once he/she has observed the motion, the learner is able to verify that the laws of dynamics are submitted to the conservation of total momentum. The user will observe the motion of the billiard ball (point ball) under the effect of a pulse obtained by applying a force f with the pool.

If we call I the impulse and Q the momentum, then known the definitions

$$I = \int_{t_1}^{t_2} f dt, \quad \text{Q=mv}$$

we have

$$I = \Delta Q$$

or rather

$$\int_{t_2}^{t_1} f dt = mv_{finale}^{palla} - mv_{iniziale}^{palla}$$

In this case seen by the student during the motion, there is no variation in mass, the impulse is constant, and the initial velocity of the ball is zero, so the scenario will enable him to evaluate that

$$mv_{finiziale}^{palla} = ft / m.$$

In other words, the student is able to discover that there is a linear dependence between the speed and applied impulse as between the speed and duration of the impulse, while the speed is inversely proportional to the mass of the ball.

4.2 Impact between ball and ball

In this scenario, the user can observe the moment of impact between the two balls and the subsequent behaviour of the same. In this scenario it is essential to define the impact parameter

$$h = \left| C_1 - C_2 \right|,$$

or rather the distance between the two centres of the spheres. In fact, changing the angle of impact, the learner has the opportunity to observe the different behaviour of the balls after impact.

So, he is able to understand that the impulse which affects the two balls is directed along the line joining the centres and is equal (in module) and opposite in direction.

4.3 Impact between ball and edge

In this latter scenario, the user will have the opportunity to observe the impact of a ball with the edge of the pool table.

Analysing the bounce of the ball in contact with the edge, it may be inferred that the change in momentum of the wall is equal and opposite to that of the particle.

In addition, in connection with the fact that the mass of the wall is infinite he/she will understand that its kinetic energy is zero (just as it is deducible by observing what happens when you play); it would imply that during the motion the ball will maintain its kinetic energy in the absence of external stimuli (such as the friction of cloth placed on the table).

The result of the simulation will be:

- The intensity of velocity is conserved during the motion;
- The impact is minor or rather $\sin\theta = \sin\theta_0 \rightarrow \theta = \theta_0$, where θ, θ_0 represent the angle that the direction of motion of the point sphere shape with the normal to the edge (in the plane of motion) respectively after and before impact.
- The impact suffered by the sphere is equal to the opposite of the impulse suffered by the wall, with a value of $I^{sfera} = -2mv_0 \cos\theta_0 \hat{n} = -I^{sponda}$

Conclusion

At present, in the learning context, there is a growing need to create contents containing educational materials capable of involving and exciting the viewer. The goal is not only to involve in the user's didactic experience as many senses as possible, via multimedia contents, but also to affect these senses. In other words, the aim is to affect a deeper realm of the ego in order to improve the interaction with the e-learning platform and to provide more meaningful, engaging and emotional educational experiences.

From this analysis results the need to develop expertise and technologies in order to increase the emotions resulting from learning experiences. This way the authors can be provided with new and improved tools to create immersive environments for the user-Simulator (learner). In this paper, we showed how to deduce the phenomena of the theory of collisions with a particular simulation. The simulation was carried out using the software Mathematica version 6.0.

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