Report

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Abstract

This report describes the development of a Smart Object used as an interface for CAD-programs or computer games. The main idea was to develop a more intuitive device than the existing products on the market like the 3D mouse. It is achieved by integrating an inertial measurement unit, a touchpad, a microphone and a Bluetooth interface in one small device. In the first step the existing technologies and products that are state of the art are analysed. Furthermore a marketing strategy is developed. Also ideas were collected for development, how to produce and sell the smart object in a sustainable way. In addition project development is described for constructing the object, setting up the sensors and programming the software. To test all sensors and to demonstrate the solution a Java application is used on the PC (Personal Computer) side.

Glossary

Arduino is a microprocessor that is commonly used for prototyping or for educational purposes.

CAD-Programm computer-aided design -program , is a computer program that is used for 3D modelling.

FIFO First In First Out– the first data to be added to the queue will be the first data to be removed.

IMU Inertial measurement unit, the sensor that measures movement using accelerometer and gyroscope.

Java object-oriented programming language, that we used on the PC for 3D modelling and a Bluetooth connection to the SO.

MEMS Micro-electro-mechanical systems.

Introduction

Progress in technology, especially in fields of embedded systems, communication and sensor systems, give rise to new types of applications and devices. Also MicroElectrical-Mechanical Systems MEMS, where very small mechanical devices allow on chip measurement of acceleration and rotation are part of mass market product nowadays. This has led to a price reduction and allows to combine several sensor technologies to test new methods of human computer interactions.

The goal is to develop and construct a smart object for an interaction with a virtual environment. The main purpose of the object is a professional use for CADProgramm (Computer Aided Design) or as a

helpful device for smart product presentations. Second the interface could be used as an intuitive game controller. The user will be able to rotate the model by rotating the object, to zoom in and out with a touchpad, and to give voice commands.

Problem

The existing computer interfaces are bound to the table tops like the computer mouse. The user has the 2D movement freedom in x- and y-axis. The computer mouse hasn't changed a lot from the day it was invented. The user still holds his/hers hand on the mouse and moves it on a table. [1] The idea is to make the movements free and versatile

Motivation

Motivation to build a wireless interface came from the fact that we all are computer users and that freedom of movement that our product offers is innovative. We want to "free" the users from the table tops and give them liberty of movement.

Objectives

Our tasks are to design a object that can be used for a PC interface. We choose the materials, the methods after reserching the existing products that fit with our needs. We aim to make users life easier. For example use it to replace a joystick, SpaceBall and racing wheel.

Expected Results

When using the Smart-Object (SO) the user will be able to turn, rotate, zoom in and out when modeling an object in CAD (Computer Aided Design)- programs. When the user is holding the object in his hand, the movement is detected by an IMU (Inertial Measurement Unit) and then transmitted via Bluetooth to the PC (Personal Computer). The product has a wireless connection to the user's PC. The product will have a battery that is rechargeable using an USB- cable (Universal Serial Bus).

Work Plan

During a semester spent at ISEP (Instituto Superior de Engenharia do Porto) on European Project Semester our group developed the Smart Object. This project gave us an opportunity to connect our knowledge from our fields of study with practical skills and work in a team, like in real life situations. This project gave us a chance to know other cultures, cooperated with foreigners and practice English. Moreover we learned new things from each other and from supervisors. The group consists of Anna, Jana, Toomas and Hannes. Anna is from Poland, she studies Engineering Management in Management and Organization faculty. Jana is from Lithuania, she studies Engineering Printing in Mechanical faculty. Toomas is from Estonia, he studies Engineering Materials and Marketing in a Mechanical faculty. Hannes is from Germany, he studies Mechatronics in a Mechanical faculty. In this project Anna is responsible for the marketing part. Jana uses her knowledge of CorelDRAW program. She will create all that is concerned with graphic design works such as poster, logo and leaflet. Toomas does

drawings in CAD- programs and he is our material specialist. Hannes will do all programming part. To facilitate the work we created a Gantt chart. We did a task list and put this task in time. Every task is defined by a start and end date in Gantt chart. This will allow us to organize our work time.

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Table of tasks

To everything went with plan and everyone know what to do we divided the tasks among group members.

Task	**Responsible**
Research	Jana, Anna, Toomas, Hannes
Make the final list of materials	Jana, Anna, Toomas, Hannes
JAVA modeling	Hannes
Preparing interim report	Jana, Anna, Toomas, Hannes
Drawings	Toomas
Building	Jana, Anna, Toomas, Hannes
Programming	Hannes
Interim report	Jana, Anna, Toomas, Hannes
Testing	Jana, Anna, Toomas, Hannes
Marketing	Anna
Video, Poster and Design works	Jana
Paperwork on deliverables	Jana, Anna, Toomas, Hannes
Upload all deliverables	Jana, Anna, Toomas, Hannes
EPS final assessment	Jana, Anna, Toomas, Hannes

Structure of the Report

The first chapter presents the problem, the motivation, the objectives and the expected results. In the second chapter the work plan of this project is explained. In the third part a short review of the state of art of the technologies that could be use are given. After that marketing plan is presented, including a market analysis and a SWOT analysis. Chapter 6. describes the state of the project development. It includes the design and construction of the device and also the programming of the object, the data connection and the representation in a virtual environment.

State of the Art

Microcontroller

Arduino

Arduino is a popular open source single-board microcontroller, it is designed to make the process of using electronics in multidisciplinary projects more accessible. The hardware consists of simple open hardware design for the Arduino board with an Atmel AVR processor and on-board input/output

support. The software consists of a standard programming language compiler and the boot loader that runs on the board. [9]

Sensors

IMU

IMU is an electronic device that measures and reports on craft's velocity, orientation and gravitational forces it uses a combination of accelerometers and gyroscopes. Typically they are used to maneuver aircraft, including UAVs (unmanned aerial vehicles), among many others and spacecraft, including shuttles, satellites and landers. It is also the main component of internal navigation systems used in aircrafts, spacecrafts, watercrafts and guided missiles. In this capacity, the data collected from the IMU's sensors allows a computer to track a craft's position. In our project we are going to use the IMU for sensing movement we translate that sensor input so that it is applicable in a CAD-program. [8]

Touch screen

Touchscreen is an electronic visual display that can detect the presence and location of a touch within the display area. The term generally refers to touching the display of the device with a finger or hand, it can also sense other passive objects such as a stylus. Commonly the touch screens are in game consoles, all-in-one computers, tablet computers and smartphones. It has two main attributes, firstly, it enables one to interact directly with what is displayed, rather than indirectly with a pointer controlled by a mouse or touchpad. Secondly, it lets one do so without requiring any intermediate device that would need to be held in the hand (other than a stylus, which is optional). [11]

Power supply

To power a wireless device we can use solar panels or rechargeable batteries, other options would be too difficult to implement.Lithium-ion polymer battery- LiPo battery Li-Po batteries are rechargeable batteries, they are usually composed of several identical secondary cells in parallel to increase the discharge current capability.[12] Solar panels A solar panel is a packaged, connected assembly of photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. A photovoltaic system typically includes an array of solar panels, and inverter and sometimes a battery and or solar tracker and interconnection wiring. [13]

Wireless data connection

Wi-Fi:

Wi-Fi is a technology that allows an electronic device to exchange data wirelessly over a computer network, it includes high-speed internet connection. There are a lot of devices that can use Wi-Fi, such as PC, video game console, smartphone, tablet or digital audio player. All of these can connect to a network resource such as the Internet via a wireless network access point. Indoor use the range is about 20 meters and outdoors it's greater. Access point, also called hotspot, coverage can comprise an area as small as a single room with walls that block radio waves or as large as many square miles - this is achieved by using multiple overlapping access points. [5]

Bluetooth:

Bluetooth is widely spread wireless connection option, it can be found on PC-s, smartphones, laptops etc. It is used for exchanging data over short distances from fixed and mobile devices. Bluetooth creates personal area networks- PANs with high levels of security. [6] ZigBee: ZigBee is intended to

be simpler and less expensive than other WPANs, such as Bluetooth. It is targeted at radio-frequency applications that require a low data rate, long battery life and secure networking. ZigBee is best suited for periodic or intermittent data or single transmission from a single transmission from a sensor or input device. [10]

Related Projects and Products

For the same purpose one can use 3Dconnexions 3D mouse. The user can rotate, zoom, turn and pan the object when using it. The 3D mouse resembles a joystick a device that is placed on a table. From the products homepage one can find this sentence: “It’s a level of control that’s simply not possible with a traditional mouse and keyboard”. They launched their first product in 2009. 3Dconnexions has 5 different products that can be used for the same purpose the difference is in segmentation. [7]

Conclusions

For the wireless data transfer we will choose Bluetooth because it is built in most of the computers and smartphones. If we are planing to use ZigBee the users should buy a software and a receiver for that. Wifi would consume the biggest amount of energy so we exclude it because of that. Our main competitor is the 3D mouse the company that produces it has several products segmented for different customer groups. They differ in size and functions that the product offers.

Marketing Plan

After the development of the Smart Object is finished and the production has started we have to put it in the market. Our company will be called Smart Interfaces JATH – name of company should say what is our industry and JAHT because these are the first letters of our names. Nowadays in order to sell the product it is not enough to produce it. If we want to sell our product we have to concentrate on customer, cost, communication and convenience. It is important to concentrate on meeting the needs of our customers. Moreover an observation of the market is necessary to recognize changes on the market. To do it we need some special tools and analysis.

The market environment analysis

In general two types of environment are distinguished: micro and macro. Firstly we will analyze the micro environment, which includes the company’s internal environment, suppliers, marketing intermediaries, customers, competitions, publics. Secondly we will analyze the macro environment.

Micro environment analysis

Our product will be made of high quality materials and we are trying to get a modern and innovative solution. Furthermore it is important to know, that there are no identical products in the market. In the first phase of the project our supplier is ISEP. If the product goes in production we are going to address a mass market. When we are introducing the object to the market we will need some suppliers. We have to remember, that all companies which are cooperating with us, are going to be checked carefully. Important things are the price and quality of resources and time of delivery.

The product will be advertised and sold on the Internet. The distribution will be done by a logistic company. The object is small so we can put it into special package which prevents damage.

We can identify the market by:

• Type of goods traded: market for goods

• According to geographical: now local in the future could be global

• According to the criterion of scale or size of transactions: retail but in the future could be wholesale

• According to the character of the merchandise: goods and services

• According to the degree of satisfaction of needs: consumer

Competitors

At the moment the same product that we are offering does not exist in the market. But the market for smart electronic devices, that simplify life is huge and rapidly growing. However, one competitor for our product can be the 3D mouse. 3D mouse devices generally function through ultrasound and provide at least three degrees of freedom. On the market there are a lot of companies producing 3D mouses. The product is gaining popularity. An Example of such a product can be found on the Internet: http://www.3dconnexion.com/products/what-is-a-3d-mouse.html The price of this product depend of its complexity and varied between 99 to 399$.

Our product is more innovative, because one can also use voice command and the user can hold it in his/her hand. It does not have to lie on the table, but it can. The other competitive product is the Wii Remote. It is not our direct competitor, but the product uses some same components and it can be used for the same purposes. The Wii remote is used for games. It is the primary controller for Nintendo's Wii console. Wii Remote has a motion sensing capability, which allows the user to interact with the game and manipulate items on screen via gesture recognition and pointing through the use of accelerometer and optical sensor technology. Another feature is its expandability through the use of attachments. The attachment bundled with the Wii console is the Nunchuk, which complements the Wii Remote by providing functions similar to those in gamepad controllers. This is an example of the Wii Remote:

http://www.gameseek.co.uk/images/products/official_nintendo_wii_remote_wii.jpg .

Another product is the typical gamepad. It is a type of game controlled, held in two hands, where the fingers (especially thumbs) are used to provide input.

http://images.speed-link.de/prodpics/_spl/SL-6555-SBK-A/large/sl-6555-sbk-a_rgb_004.jpg.

However, these two products can be used only for gaming. So our product can be distinguished from the exiting product, because it gives more possibilities and can be used for a professional purpose and also for fun.

Macro environment analysis

Macro environment includes demographic, economic, natural, technological, political and cultural forces.

Demographic forces result from population age structure, sex structure, etc. Our product is addressed particularly to professionals and in near future (one year strategy) to younger people (between 17 to 35 years) , because they follow the course of time more. For example young people play games which need a certain freedom of movement that comes from our product. Professionals, who work a lot with computers need a product which gives more possibilities than the ordinary mouse. These people can work for example in design field, as engineers, architects, designers.

Economic forces stem from the overall economic condition. Nowadays in many countries there is the economic recession. In this phase of development we are not 100% sure how much our product will cost. We plan that will be cost around 300€. However we would like that the price is not higher than the price for a professional 3D mouse, which is around 400 €. But we also do not want to sacrifice quality.

Technological forces are arising from the level of technological development. Currently technological progress is huge. It is a threat, sell new version and earn money, but it can be threats because if the company does not track the development of competition, market it is easy to be left behind.

Political forces: In our opinion the EU is a good place to produce, buy and sell electronic products, because the EU has similar standards for production, quality and sales of products and services.

Cultural forces result from the prevailing fashion, lifestyle or habits and culture prevailing in the area. Nowadays everyone has at least one computer, mobile phone or iPad. Our product can cooperate with any of these devices.

To summarize the environmental analysis we did a SWOT analysis. In our case we will focused on our company which is our team and our product which is the Smart Object.

The following table shows the SWOT analyses:

Strengths	**Weaknesses**
•ability to think logically	• problem with communication
• use new technology	• lack competitive edge
• access to well-equipped laboratories	• inexperience
• quality of product	• lack of a position in the market
• own sales network	• only advertising on the Internet
• sales by Internet (7days a week, 24h per day)	• small financial resources
• possibility of selling the product around the world	• instability of the production line
• good quality of materials used in production	• need to build a positive image
• modern solutions	• difficulty with the first customers
• functionality of the product produced	• short product life cycle
• human potential	
• average price of product	
• possible to adapt the	
Opportunitiess	**Threats**
• patronage of ISEP	• unemployment
• opportunity to work with a qualified people	• low income of society
• ISEP-s good reputation	• rapid development of technology
• demand for such products	• increasing competition in the market
• EU membership	• strong position of technology leaders
• common currency in the EU	• existence substitute product on the market
• absorbent, growing market	• customer loyalty relative to our competitors

Market segmentation

The next step in the marketing procedure is to choose the market segment. This is important because we have to know the needs of our customers to meet them. Market segmentation is to make a distribution of the market into a relatively homogeneous group of consumers, because of the

similarities of characteristics reveal a similar demand. Knowing the target segment will help us to prepare a product that meets the needs of our clients and helps us to obtain advantage in the market.

We see chance for our product in two segments. The first one is people who are working with engineering programs meant for drawing. They are designers, architects or engineers. But not only this product can be addressed to teacher and students who use engineering programs. They spend a lot of their time using computer to draw sketches, diagrams, plans and models. Our product can facilitate the implementation of these activities. We are particularly interested in this segment but in the future we plan entrance on the next one. The second target group can be young people (17-35 years) who use their computers or mobile phones to play games. Our product gives them freedom of movement. Moreover young people like modern things and technical innovations.

Objectives:

• meet customer needs – satisfied customers 90%

• achieve operational excellence in the internal processes of marketing, supplier, product development, logistics

• make that brand recognizable about 30% in the end of year 2013

• occupy 20% of the market by the end of 2012

• by higher sales reduce the price of the product about 10% when our sales rise to 20 000 pieces

• enter in new target after first year on market

• expand product lines (new version of product) after first year on market

Basic marketing strategy

Marketing strategy comprises actions and producing plan, the sales of the product and dealing with problems. The prototype is produced for the ISEP, but the product can be sold in open market. Our Smart Object is addressed to older workers as designers, architects, engineers, teachers, etc. We are going to sell our product on the Internet, because this distribution way is cheap and we are able to address a big market. We do not have to rent space in the shop. Our offer will be in website, we want to generate a bookmark with the product order form. Moreover on our website we would like to place a description of the product along with photos and video illustrating the use of the product. The website will be in Portuguese, English and German language. We will pay for position in Google. We are thinking about place to advertising on complementary products for example: PC, drawing programs, etc. That will be a source of additional earnings. If we have to think about distribution, we use companies in the fast delivery of mail, shipments of goods and advertising. The object is small so we can put it to special package which prevents damage. If our product will be well received by users of ISEP, we would like to sell it on a broader market. If there is a big demand for our product we can afford to cut prices. When it comes to promotion we will do posters and some leaflets. We address it to workers and students, so they should be professional and factual.

After first year of existing our company we are planning enter new target. This target group will be young people (17-35 years) who use their computers or mobile phones to play games. Our product gives them freedom of movement. Moreover young people like modern things and technical We plan make minor changes to lower price. We are thinking about two types of advertising. We want all time keep advertising for first segment and created advertising for second one. Advertising for young people should be more modern and we can do some animations, 3D effects, etc.

If we think about the long-term strategy (three years) we would like to develop a product line. For example we can develop a product for professionals with very precise sensors and a support for many engineering software. Another aspect is the aesthetics of the product. It is possible to extend the color variations of the product, change shape or do our product smaller to better fit a woman's hand and to meet the need of young consumers. We extend our offer also for various types of connection to the computer object, it need not be only Bluetooth, but we can use WiFi or ZigBee.

Marketing MIX

Marketing mix is a business tool used for marketing products. It is composed of four Ps/Cs .

• Product / Customer

• Price / Cost

• Promotion / Communication

• Place / Convenience

Ad1. Product / customer

One can use the SO as an input device for CAD-programs. By using the device one can turn the model (with the sensor data) in the program 3D space, zoom in and out (with touch pad) and use some voice commands (microphone). With the acceleration data the program decides if the SO is held in hand or lies on the table. The wireless connection is achieved via Bluetooth.

Ad2. Price / cost

We do not know yet how much our product will cost, but the price includes: cost of materials, cost of packaging, distribution costs, advertising costs and labor costs. But we know that we have to remember the fact that the price can not be too high because no one will buy the product. If we will have production lines we will buy materials in bulk so price of material will be lower. Advertising costs will be spread over more units so that the price of the product in mass production will be lower. As for the price of the product, we can give only the costs incurred for materials and it is around 300 € (VAT included) for the prototype. In the production stage we can cut costs already when we order materials in with bigger quantities - we save money on transport and probably get a discount for ordering a bigger amount.

In terms of the method of payment available are:

• Prepayment

• Transfer

• Check

• Credit Card and Online Transfer

The payment will be facilitated to customer preference. Furthermore we want to apply some discounts for the customers who purchase 5 units of our product we offer a discount of 5%. The customers who purchase more than 10 units of our product we offer a discount of 10%.

Ad3. Promotion / communication

Promotion is various types of advertising the product. Discovery in the clients wish to own the product and encourage the customer to buy it. Moreover it is communication with client. We would like to in this phase of project do some poster and leaflet. We are thinking about some slogans:

• Feel the corner

• Catch the corner

• touch the corner

• Feel the motion

• touch the motion

• It’s the smart thing

• See what you keep in mind

• Let’s make things better/rotate/easier

• Easy as XXX

• Control your power/motion of mind

When we generate a web page we are going to put a description of the product there along with photos, videos illustrating the use of the product. The web page will be available in Portuguese, English and German language . We will pay for position in Google, because for the clients it will be easier to find us. We want to design two types of it: for professionals and after one year for people playing games. First one should be more professional and factual. Second one can be modern and less official. If ISEP agrees we could put a link to our offer at ISEPs web page. Moreover we will have opportunities to present our Smart Object for clients in events organized by ISEP that will be cheap promotion addressed to the large number of consumers. Collaboration with ISEP gains the trust of customers thanks to their good opinion of ISEP. To attract the attention of customers and encourage them to purchase our product we want to send our product to reporters working in specialist / professional magazines. These reporters can test our product and write an objective view about it. We would like to send our product to four of the biggest professional magazines. The readers will have independent opinion about the product. Good opinions in these magazines are the best publicity. For younger people we can generate a profile on Facebook. Nowadays everyone has Facebook and get a lot of information from this page. There we can put information about our product, some simulation, prices and promotion. Users can share their opinion between then.

Ad4. Place convenience

Place is a really important thing. If you have a shop near the main street you have more clients. But currently a lot of people use online shops in the Internet. We want to sell our product in the Internet. It is better because we do not have to pay rent for the shop. It is more convenient for the client because he/she can do his/her shopping seven days a week, twenty four hours a day without leaving home. To distribute our product we use outsourcing, it is a cheaper alternative for us than creating our own department, at least at this stage. We want to sign a contract with a logistic company. Moreover we need some special packages to carry the product. This package should prevent damage. In our opinion this solution is convenient for client. They send us their order and after five days they have the product in their house. If our product don’t meet costumer needs, he/she can return product within fourteen days. This is a good solution, because it is cheap. But in the first phase of the product

life no one knows if a better solution would be to place it in the store. The client can see the product and buy it in chain stores. After signing the contract because our product is in every chain store.

Action program

We will sale the Smart Object in stores with multimedia devices and in the internet. On the first phase of promotion we are going to do some posters and leaflets addressed to all users from ISEP. In this time we are going to generate a web page. Moreover on our website we would like to place a description of the product along with photos, videos illustrating the use of the product. After that we want to do more posters, leaflets and advertising in web pages addressed to the two segments we have already presented. Advertising for young people should be more modern and we can use some animations and 3D effects. Advertising for engineers should be more professional and factual.

To promotion we want use also professional magazines. For an example:

• PCWorld: www.pcworld.com

• PCPro: www.pcpro.co.uk

• Blueprint Magazin: www.blueprintmagazine.co.uk

• DesignEngenieering: design-engineering

We will offer the magazines a free exemplar of the product to test it and to write an article about it. Another way to promote the product can be Facebook. If our promotion will be effective we can get our goals (occupy 20% of the market by the end of 2012 to do it we need sell 10 000 pieces, by higher sales reduce the price of the product about 10% when our sales rise to 20 000 pieces, make that brand recognizable about 30% in the end of year 2013). All time we have to observe situations on the market and we have to be flexible to adapt to customer requirements. If we do that we can satisfy our customers. We have to pay particular attention to the objectives set. Operational excellence in internal processes, marketing, supply, product development and logistics can be achieved through appropriate management of resources. In the next year we would like to expand product lines (new version of product) that will be possible if we sell 3 000 items. The last one but not the least is to make that brand recognizable about 30% in the end of year 2013. It can happen if we will have good cooperation with publicity and our client will be satisfied with the use of the product.

Budget

To well manage the project it is necessary to have permanent control over the costs incurred. Everyone remembers about cost of materials and employment costs but usually we forget to think about marketing costs. This cost include: advertising, leaflets, posters, websites, etc. The estimated annual costs on our marketing plan might be(only marketing cost):

• Cost of posters: 100€ per month /1200€ per year

• Cost of leaflets: 100€ per month /1200€ per year

• Cost of the web-site: 450€ (one-time cost)

• Cost of position in Google: about 35€ per month /420€ per year

• Cost of advertising in media: about 120€ per month /1440€ per year

Control

To control if our marketing strategy is successful, we have to observe all time the micro and macro environment. It is important to study the strategies of our competitors, analyze their product, promotion and clients. Otherwise we will not follow the changes and we will be left behind. We are also planning to look at customer needs and adapt to changes, keep customers and attract new. We should all the time look at offers for the materials because in the market new businesses can develop and they might have more favorable contracts. Good solution is to change your ad at least every six months to attract customers' attention. Otherwise it becomes monotonous and not effective. Another important thing is to monitor changes in macro environment. We have to be up to date with law and economical situation in Portugal and around the world. Of course the most important thing in our case is technological forces, because the technological development in these field is very fast. We must be up to date and continuously improve the product because otherwise it will be obsolete soon. Also we should follow fashion, because one of the segments is young people, and they like to be fashionable.

Moreover we have to have control on our objectives. This control will consist in comparing the present state of theoretical assumptions. To have a good control the situation we are going to prepare quarterly reports. Then we compare the results with previous ones, and the strategy plan and draw conclusions. After that we should do a plan for the next quarter and try realizing them.

Conclusion

We did a market analysis which includes micro and macro environment. After that we choose two segments for our product. First one is people who work with engineering programs that are meant for drawing. They are designers, architects, engineers, teachers and students. They spend a lot of their time using computers to draw sketches, diagrams, plans, models. Our product can facilitate the implementation of these activities. The other target group is be young people between 17 to 35 years who use their computers or mobile phones to play games. In our marketing plan we adapt our promotion to these segments. We set up goals and prepare an action and control plan, which helps us to achieve our objectives. We valued price of our Smart Object on 300€. Cost of production per one product is 230€. We plan earn 70€ per piece, but from this we have to withhold the price of transport.

Eco-eficiency Measures for Sustainibility

Eco- efficiency is one way to generate more perceptible value and profit. When we reduce the material consumption, implement the concept of energy conservation and the concept of energy efficiency we have to make investments for the future. After the investments are made we start to see the impact that they have on profit (we produce more with the same amount).

The ideal version to use the materials would be in a circular usage like shown on the picture above. After extraction they stay in the manufacturing-usage-recycling loop. When it comes to sustainable development the strategy includes the whole lifecycle of the product. It starts with the extraction and production of intermediate goods needed for further production, design of the product, the production for a massmarket, the transport and the recycling and also the culture of the company.

Design of the product

For producing the prototype the following parts/materials are used:

• outer shell (acrylic glass- thermoplastic)

• boards (silicon, metals, plastic …)

• screws/nuts (metal- stainless steel)

• Lithium Polymer Battery (Li, plastic…)

• touch screen (plastic, ….)

• standoffs (nylon- thermoplastic)

• microphone (metals, silicon, plastic,…)

• wires (metals, plastic)

In the design stage we consider the impact that our product has in the environment. Our goal is to use sustainable ways to solve the problem. Most of the parts are made of recyclable materials. From the design stage we have kept in mind sustainability. Unfortunately we can't use renewable materials like wood to make the outer shell because wood expands in contact with humidity. Moreover our product should not come into contact direct with water, it can not get wet. Wood also cracks. So we try to use materials that are recyclable. For prototyping the outer shell material should be easily shapeable and machinable. We were thinking about two materials what we could use: acrylic glass and ABS-plastic (Acrylonitrile Butadiene Styrene). Both of the materials are hard recyclable.

They both are usable for this purpose. We have easy access to acrylic glass so for that purpose we are going to use it for the shell material.All the boards and microphone are made from silicon, metals and plastic, all these materials are recyclable. The battery is rechargeable, we are going to use a USB cable to charge the battery because it can be used for other tasks also. Lithium Polymer Batteries are also made from recyclable materials and they are rechargeable. The nylon standoffs that we are planning to use are made from thermoplastics- also a reusable material. The wires are made from metal and covered with plastic.

Extraction and production of intermediate goods Metals

Stainless-steel–The screws and nuts that are used are made of stainless steel. Steels are alloys that have 0,2 to 2,1% of carbon content. Steel is one of the most recycled materials in the world. Ferrous metals contain an appreciable percentage of iron and the addition of carbon and other substances creates steel. The steel industry is recycling in large part because it is economically advantageous to do so. It is cheaper to recycle steel than to mine iron ore and manipulate it through the production process to form new steel. Steel does not lose any of its inherent physical properties during the recycling process, and has drastically reduced energy and material requirements compared with refinement from iron ore. The energy saved by recycling reduces the annual energy consumption of the industry by about 75%, which is enough to power eighteen million homes for one year. Recycling one metric ton (1,000 kilograms) of steel saves 1.1 metric tons of iron ore, 630 kilograms of coal, and 55 kilograms of limestone. [13]

Aluminium– The angle brackets are made of aluminium alloy. Aluminum is theoretically 100% recyclable without any losses in its properties. Recovering the metal via recycling has become an important part of the aluminium industry. Recycling involves melting the scrap metal, a process that requires only 5% of the energy used to produce aluminum from ore, though up to 15% of the input material is lost as dross (ash-like oxide). The dross can undergo a further process to extract aluminium. [14]

Plastics

ABS-plastic–Production of 1 kg of ABS requires the equivalent of about 2 kg of petroleum for raw materials and energy. It can also be recycled. The advantage of ABS is that this material combines the strength and rigidity of the acrylonitrile and styrene polymers with the toughness of the polybutadiene rubber.[15] ABS-plastic is group 7 plastic among recyclable plastics.

Acrylic plastics–Acrylic plastics manufacturing involves highly toxic substances which require careful storage, handling, and disposal. The polymerization process can result in an explosion if not monitored properly. It also produces toxic fumes. Recent legislation requires that the polymerization process be carried out in a closed environment and that the fumes be cleaned, captured, or otherwise neutralized before discharge to the atmosphere. Acrylic plastic is not easily recycled. It is considered a group 7 plastic among recycled plastics and is not collected for recycling in most communities. Large pieces can be reformed into other useful objects if they have not suffered too much stress, crazing, or cracking, but this accounts for only a very small portion of the acrylic plastic waste. In a landfill, acrylic plastics, like many other plastics, are not readily biodegradable. [16]

Rubber–Rubber recovery can be a difficult process, but there are many reasons why rubber is reused. Firstly the recovered rubber can cost half of that of the natural or synthetic rubber. Recovered rubber has some properties that are superior to the properties of a virgin rubber. [17]

Production

In the first year we are planning to sell 10 000 pieces of our product in Europe and USA, if we have more orders, then we may rise production. Because we want to find our first customers in EU and USA then it would be economically useful for us to start our first production factory somewhere in Europe. Because we are nearer to the end consumers and we can save on transportation costs.

There is 252 working days in a year. If we plan to make 10 000 pieces in the first year and we have 252 work days then we should produce around 40 devices a day.

To make the products shell we are planing to use ABS-injection molding. The molds and the machine are rather expensive. We also would need two mold pairs to make the the two shell halves of the product. The molding machine maybe has to work for one week in a month to produce the parts needed for assembly in that month. Therefore it would be reasonable to use another company’s services at this point to make these parts. Later, in the stage where the production amounts are bigger and we have more different products we should consider having our own production department.

All the electronical parts we are planning to order and buy in from the companies that produce them. So at first we would only do the assembling the products.

Our production volume is small at first, so we should not consider moving out from Europe before it grows up to 50 000 pieces per year or more (200 pieces per day, if we have 252 workdays). The factories have to comply to all the rules and regulations for the environment protection. Also we have to introduce safe methods of working to exclude work related accidents and injuries. All the employees get a fair salary because we need their special skills and to show that we appreciate that. The salary consists of baseline salary plus bonuses that motivate employees to be more productive. We are thinking to employ maximum of 40 people in the beginning.

In production we see some solutions to be more ecologically friendly and sustainable. With the production plan and appropriate management of materials we can save materials, that is to say reduce the amount of waste generated during the production. If we will employ qualified staff they will know how to do their job, so they will make less mistakes. Consequently there will be less

defective products and less waste. Work should be planned so that the machinery and equipment is not turned on for nothing - not to waste energy. But it is also important not to stop them too often, because it wastes time and energy to start them again. Moreover we can design production halls so that road transport is as short as possible. We also have to consider the supply of raw materials. If we order larger batches of materials they will not have to be so often transported. In our opinion a good idea could be taking the materials from local suppliers because, firstly, cost of transport will be less and transportation of materials will be much lower. Secondly, this solution gives employment to local community and will develop the region economically.

Packaging, Recycling and Transport

Our products packaging can be made completely from recyclable materials. The package can be made from cardboard, in the middle of the box there is a special bracket that is supporting the Smart Object and protecting it against damage. The package can be recycled again.

When it comes to supplying our product to the customers we want to use a logistic company with the highest standards of environment protection. They have to use modern cars that have low fuel consumption and low CO2 emission.

General outsourcing saves costs. This is the main reason why choose a logistics company to distribute the product. Also it is more sustainable. Because if the company provides products it would send cars with only one package at a time. When using logistic companies, they send cars full of different packages to the same area. When using logistic companies they transport our products to the customers and other packs in the same are.

Conclusion

The plan is to use recyclable materials for packing the Smart Object. After buying the product, the consumer can throw the package to recyclable materials container. To distribute the product the plan is to use logistics companies that have already invested in the labor force and equipment for that. The idea is to use a economically friendly logistics company.

Project Development

This chapter describes the state of our product development, this includes the system architecture and hardware specifications. The main part of the object will be an Arduino microcontroller. The board will be connected to different sensors. Main part of the sensor system will be an IMU (inertial measurement system), to get a full 6 degree of freedom measurement of the position of the object. The sensor data will be transmitted to a PC over a wireless data connection. On the PC the object is modelled in a virtual environment. The programming language for this part will be Java.

System Architecture

All the parts are inside the outer shell except the touch screen. The outer shell will be made from acrylic glass that is machined and bent to the needed shape. There are several holes and openings machined in for bolts and parts, the corners of the object are bent. The shell is screwed together because we are making a prototype and there might be a need to reopen the shell. Also the parts and components are screwed together like seen on the picture below. In the picture you can see modelling stage of Smart Object.

Hardware Specifications

Typical modern wireless devices contain the following building blocks: A controlling platform with a CPU, sensors, wireless communication interface, memory anda power source. In this project we chose these blocks considering the following constraints: price, ease of use, flexibility and energy consumption.

Arduino BT

The Arduino BT 6.2 is a microcontroller board based on the ATmega328 and the Bluegiga WT11 bluetooth module. Main features a a wireless serial communication over Bluetooth, 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a 32 KB Flash Memory and 2 KB SRAM. [18] The picture shows the Arduino BT.

IMU Digital Combo Board - ITG3200/ADXL345

The IMU 6.3 offers a 6 degrees of freedom measurement. The communication is solved over I2C with the Arduino. The picture shows IMU Digital Combo Board.

ITG-3200 Integrated Triple-Axis Digital-Output Gyroscope The Gyroscope is single-chip, digital-output, 3-axis MEMS gyro optimized for gaming, 3D mice, and motion-based remote control applications. It features three 16-bit analog-to-digital converters (ADCs) for digitizing the gyro outputs and a Fast-Mode I2C (400kHz) interface. The Digital-output X-, Y-, and Z-Axis angular rate sensors have a sensitivity of 14 LSBs per◦/sec and a full-scale range of ± 2000◦/sec. [19]

Digital Accelerometer ADXL345 The ADXL345 is a small and ultra low power 3-axis accelerometer. It measures thestatic acceleration of gravity, as well as dynamic acceleration resulting from motion or shock. The measurement is done with a high resolution (13-bit) at up to ±16 g. The data is formatted as 16-bit twos complement and is accessible through a I2C digital interface. The resolution of 3.9 mg/LSB) enables measurement of inclination changes less than 1.0◦. [20]

Information Flow from the Sensors to the PC

The movement of the object is registered by an IMU. IMU sends that data to Arduino. At last the Arduino board sends the data via Bluetooth to a PC. The microphone registers the voice input and sends it to the Arduino. The Arduino sends the data to a PC via Bluetooth. The touch screen detects the input (touch) and sends it to breakout board. In the end the data is sent to the Arduino and from there it’s sent to the PC via Bluetooth.

Programming the Smart Object

The programming part of the SO can be divided in two sections. On the device side we have the Arduino program, written in C. The programming language on the PC side is Java. To get a powerful amount of functions we use a Java OpenGL engine called “jmonkeyengine” [21]. To develop the Java program we use the open source software Eclipse [22]. Figure 6.6 gives a overview over the software architecture. The Java application is separated in three parts. A data management thread for the serial Bluetooth connection, a thread to visualize the 3D-environment and the cube and a thread for plotting the sensor data.

The Arduino Program

The program is structured like the typical Arduino application in a Setup and a Loop part. In the Setup the Serial Connection is established. Furthermore all the digital and analog ports, which are

connected to the sensors, are defined. At least an array of double values is allocated for saving the sensor values. After the Setup the Loop starts to run. The first step in the Loop is to check, if a connection to the PC exist. If not, the Arduino has to do nothing. If a connection exist, the values from each sensor are called. For the IMU a library is used, that can be found here: [22]. The library was very helpful and makes the IMU easy to use. Inside this software, the gyro values and acceleration values are fused together to calculate a more stable position. As one result it is possible to get directly the Euler Angles of the sensor. The touchpad is directly connected to an analog port, but it is not possible to read x- and y-position at the same time, because a special pin configuration is necessary. After reading the touchpad position, the microphone value is read, which is also a analog read.

Data Management Thread

The thread is used to create the connection to the SO. The used Bluetooth profile is a serial connection. If the Bluetooth connection is working, all incoming data is stored in 3 different FIFOs (First In First Out). The FIFOs are declared as public. The implemented data structure is thread save, to avoid data crashes. This is necessary because multiple threads have to access the data.

Game Engine Thread

The Game Engine Thread implements the OpenGL game engine. After setting up the world and creating the cube the thread trys to get data from the data management thread. If data is available a loop is started to permanently update the visualization. To detect the zoom, the touch pad data is analysed in a separate function. If the values are decreasing or increasing the zoom value is calculated new. By analysing the acceleration data for big chnges in a short time period, a shake of the object can be detected. With this information two modes are implemented. In the first mode the cube can be rotated. In the second mode the camera around the cube can be rotated. For both modes the three Euler angles from the IMU are used to change the rotation of the cube or camera.

Plot Thread

The thread is used to plot the sensor data in real time. If a new value is added to the FIFO of the data management thread, the plot thread adds a time stamp to each value and refreshes the plot. Each plot is added to tab of a tabbed pane in the Java application, so the user can easily switch between the different plots or the object visualisation.

Building and assembly

Building angle brackets

The plan was to buy the angle brackets that suited the best with our needs. Unfortunately we couldn’t get them. The angle brackets were made from an aluminium alloy L-profile. The L-profile had to be cut in 20 mm wide pieces and then two holes had to be drilled into each angle bracket for the screws. The first hole drilled was 2 mm in diameter and the second one was in 3 mm in diameter. Files were used to make the edges surfaces smoother, because a metal saw was used for the cutting. Angle brackets for the bottom part had to be smaller from one side so that the Arduino could be taken out if needed.

Bending the Acrylic glass parts

For bending acrylic glass some heat source was needed. ISEP doesnot have a machine or some other

device meant for that. In the Electro Mechanics laboratory the university had some devices that could be used for this purpose. Before bending, the parts were cut into size and some small cuts were made where the bending line should run, the cut was 0,3-0,5 mm deep. This cut relieves stress that the bending causes. The small cut should be made on the side that is going to be inside of the bent corner. A voltage regulator was used to heat up a wire that was fastened between two clamps. The wire was couple of mm (3 mm) hire then the piece of acrylic sheet. At those circumstances, after testing, was found that the best bends can be made with 3.1 V and 11.8 A, at this point the wire was around 400 deg C. This suited best with the 3mm thick acrylic glass sheet that was used and the heated part didn't have any bubbles. There was also a problem with the wire it started to bend because the material elongated when the temperature grew. The solution for that problem was that it had to be held under tension manually to avoid that.

Machining the acrylic parts

The holes for the screws were drilled after bending the acrylic parts, this was done to achieve higher precision. Chamfers were made so that the screw heads would be at the same level as the acrylic. A drilling machine was used for this purpose. Also some holes were made for the touchpad connector and the hole for the USB cable to charge the assembled device. The top and bottom parts were cut into size, the sides and corners were grinded and filed. Then the holes for the screws were drilled. Chamfers were also made to hide the screw heads.

Assembly

To assemble everything different screws, washers and nuts are used. The angle brackets hold together 4 acrylic glass parts that form the shell. Two types of flathead screws are used to fasten the angle brackets to the acrylic: metal screws and M3 screws. The metal screw is screwed straitly in the angle brackets 2 mm diameter hole. The M3 screw goes through the 3 mm diameter hole and is fastened with a nut. To fasten all the electronical things to the acrylic M3 screws, rubber washers and M3 nuts are used. The M3 screw is fastened to the acrylic with a nut. This method should relieve some stress from the electronical parts. Then the electronical parts are but between 2 rubber washers and to hold them in place another nut is used. The last nut is loosely fastened on the screw to keep the electrical parts in place.

The touchpad is taped onto one side of the shell. The touchpad pin goes through the hole that was made before into the acrylic glass. The connector is placed inside the shell. When the Smart Object is assembled it looks like seen on the Figure below

Conclusions

This report presented the work done on the Smart Object and the achievements made by the team of international students who attended the European Project Semester in ISEP. The teamwork was not easy because of several reasons. One of the reasons was collaboration with people from different countries and customs. Sometimes we had some communication problems and different ideas how to solve some problems. With time we got to know each other more and more and the teamwork got better also. Now after four months we know our and teammates strengths and weaknesses. Thanks to that we know now better how to divide the tasks between ourselves. This project gave us an opportunity to combine our theoretical and practical knowledge. Also all of us have now a better understanding what it means to work in an international team.

We had many ideas when we began working on the Smart Object. Starting from defining the functions

and ending with the material selection. Making these decisions was not easy but when it came to the building all went smoothly. The Smart Object should facilitate work with CAD-programs. This described object consists of three parts: (1) Arduino microcontroller, which connects with board of sensors, (2) an IMU (inertial measurement system) that gets a full 6 degree of freedom measurement of the position of the object, and (3) a wireless data connection and a virtual environment which is programmed in JAVA. We also wanted to show other aspects of developing project/ product, like the marketing plan and project management. We had some problems during the work with Arduino, touchscreen, IMU, microphone and many others but we found solutions and now we can say that our Smart Object is working.

Future Developments

The product has to be made more marketable, at the moment the prototypes shell is made of acrylic glass. This material is not suitable for mass production. When the Smart Object is going to hit the market the shell should be made from a moldable material like ABS- plastic. A lot of appliances and electronic devices have enclosures made from ABS-plastic. The material is tough and has a good impact resistance. The material can be easily molded with proper machines. Also the outer design should be more attractive, at the moment it looks like a box where we can put our hardware. Also the product can be made smaller. At the moment Arduino BT is used as a microcontroller it is ideal for prototyping. The microcontroller can be also a lot smaller because it is specially made to fill the given tasks. Also the barrey can be more compact to take as few space as possible.

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