



Make it simple. Design a TV remote control with intuitive use.

Christos Varnas

International Hellenic University

Make it simple. Design a TV remote control with intuitive use by Christos Varnas

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Student Name: Christos Varnas

ID: 1106170032

Supervisor: Mr. Athanasios Babalis

I hereby declare that the work submitted is mine and that where I have made use of another's work; I have attributed the sources according to the Regulations set in the Student's Handbook.

*I would like to thank my professor, Mr. Athanasios Babalis
for his guidance and continuous help,
and also my family for
all the support.*

Abstract

The primary focus of this study is to create and present an intuitive for human use remote control. Academic and other research examined in the first part. Additionally, customer reviews current remote controls were also studied.

In the second part, the design part, concepts were introduced to potential users so as to proceed to the final design and its specifications.

During the whole process literature concerning simple design was taken into account.

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Part 1 – Research Phase

1. Introduction

The aim of this study is to improve on a TV remote control by resolving its complexity. The main purpose is to create an unobtrusive and understandable product, giving the opportunity to the potential user to get easily familiarized with it. Therefore the final product is expected to have a great appeal to various target groups including elders, people with disabilities or even people with a little experience in using electronic devices.

1.1 General Topic and Hypothesis

People every day use tons of products with various features and characteristics. It is true that with today's constantly developing technology, new generation of products is introduced to the market frequently. As industry becoming more and more aggressive and companies trying to acquire competitive advantage the offered devices are better and increased in reliability. However when consumers understand the use of those products newcomers try to provide products that exceeding their predecessors, adding even more attributes and always at the expense of added complexity. *Technology has made our lives more full, yet at the same time we've become uncomfortably "full" (Maeda 2005)ⁱ.*

Most of the people have been confronted with the situation of using another's person TV and couldn't tame with complexity of the different kind of remote controls. Another question comes up if people think about how many buttons of their remote control they actually use when they watch television in their everyday life. Many controllers have dozens of buttons containing some with strange labels such a "NAVI" or "SET" that users do not know their function and admittedly do not handle them.

Electronic devices technology is getting better before customers understand and adopt the new features. There are cases that people pay for a very expensive high definition television and watch their program on low resolution because they simply do not have the proper knowledge to operate them. Small lettering, incomprehensible signifiers with no obvious explanation and other problems that going to be analyzed later are so problematic that can make the use of remote control really frustrating sometimes. Common used commands such as power on/off or turning the volume up/down are placed among other buttons, that users don't use frequently driving them to undesired behaviors and mistakes. So, another issue that has to be solved is the organization of controllers' operation structure in order to create an attractive and user-friendly product.

It is an undeniable fact that product design and especially product appearance and shape increase the product value and the possibility of providing a successful product. Design of products has not only to be aesthetically pleasing but also to make the product understandable to the user. The main purpose is to provide functional

products which offer intuitive experiences and being comprehensible at no time. A sense of simplicity and familiarity can help in order the previous fact to be true. But what is simplicity? *Simplicity is about subtracting the obvious and adding the meaningful (Norman 1998)ⁱⁱ*.As a result the research presented in this study conducted in order to define the designing of an everyday product like the TV remote control taking into account the simplicity laws. Cases concerning existing products are going to be analyzed so as to create a self-explanatory and intuitive product.

1.2 Research Questions

It is a great argument that remote controls have simplified the use of TV, but also there are various problems referring to neither the design nor the structure of the abovementioned product that should be solved. Herein in this study the design of the remote control, the user difficulties, the complexity of the product and the materials that have been used will be analyzed.

In order to design the desirable device the following questions have to be answered:

- Which are the main problems of the existing products? Concerning to the fact that most of the electronic devices features are frequently improved, the examination of the current remote control problems is demanding.
- How can we design self-explanatory, intuitive products? Most of the users are elders or kids who cannot adjust to the use of complex products. Thus, another challenge of this study is to simplify the design of a remote control.
- Which are the main needs of the potential users?
- How can the product be aesthetically pleasing and functional at the same time? Designers have to provide intuitive for human use products taking into account not only aesthetics, but also usability.

2. Previous academic and other Research

2.1 A COMPARATIVE STUDY OF REMOTE CONTROLS FOR DIGITAL TV RECEIVERSⁱⁱⁱ

(By Jane Lessiter, Jonathan Freeman, Andrea Miotto, and Eva Ferrari)

This research was held in order to examine the usability of three remote controls that operate a digital set top box. The study concerns users who confront a lot of difficulties in the access and use of digital television apparatus.

The sample consisted of 35 people divided in three groups: The first group comprised by 12 elderly people, aged 75+. In addition to that, people with health problems like visual dexterity and other age related problems, were added. The second group named “cognitive” included people with various learning impairments such as ADD, Asperger’s Syndrome and Autism. The last group (called “young”), was a team of 12 adults, under 45 years old without any problem either sensory or physical.

The study focuses in the usage of plenty variations of features people use in remote controllers such as button size, shape, texture, functional grouping and positioning. Users were inquired to test the controllers by executing a series of 12 everyday typical TV-tasks.

These assignments were presented in a logical structure based on the sequence that they might be performed. The tasks ranging from basic use tasks such as changing channel, interactive use like “exit a menu” and access service use (actions like enabling subtitles).

The basic criterion so as to understand the complication of the task was the time of identification of the correct button.

“Time was recoded into one of five categories [A=Pass <10s; B=Pass 11-20s; C=Pass 21-30s; D=Fail >30s (time out); E=Fail, participant gives up]”



The remote controls used at the survey

“Across all groups participants performed fastest with remote control 1, then remote control 2, then 3 (From the left side to right in the picture above)”.

At the end of the trials, participants were asked to examine and evaluate the remote controls based on criteria like which was their favorite, the most expensive and which matches better with the remote they use at their home. Moreover attractiveness and ease of use ratings gathered.

The results of the study were the following:

Participants understand better and use easier the remote controls that met Core Receiver Requirements. Additionally adults aged over 75 years, with a range of impairments had the most difficulty using all 3 remote controls

An interesting result is that people aged over 75 years faced a lot of difficulties using all three remote controls. That means that elderly people, who represent a large percentage of the television programs audience, and people with disabilities confront with many problems. On the other side the “young” group completed the required tasks in less time with each of the remote controls. Of course the young group was faster than the “cognitive” group too.

Another important aspect is that the 75+ group stated that the most difficult to use remote control was the one with the identical buttons. On the other hand remote

controls with variation in button sizes, shapes and height met the design guidelines of intuitive products and were easier to use.

Similar proportions of adult participants aged over 75 years, with a range of impairments, successfully completed usage tasks within the designated time limit using remote controls 1 and 2; they were less able to complete usage tasks with remote control 3.

For the task of switching on/off, remote control 1 was preferred than the others because remote control 2 has two power buttons (one for the TV and one for digital boxes). However changing channels was easier with the second remote control. This happened due to the fact that the “zero” key in remote control 1 was placed in an unusual for the audience place.

Concerning the attractiveness ratings there were no significant differences on user preferences. However the survey showed that except the 75+ group – which found all the remote controls aesthetically similar – the “young” and “cognitive” group had some preferences.

For the “young” group: 3 then 2 then 1

For the “cognitive” group: 1 then 2 then 3

(Best to worst)

Last but not least a very important statement is that the 75+ group did not think that any of the remote controls tested is a product with intuitive use.

2.1.1 Research 1: Discussion and Conclusions

After the analysis of this particular survey a lot of conclusions were drawn. Firstly, taking into consideration the basic criterion of this study – the time of button identification - we totally understand the importance of visibility in product design. Products with visible cues are easier to operate and intuitive for human use.^{iv} When we say “visible cues” we mean signals that provide the user with the required indications in order to use the product smoothly. Poor designed objects are those objects that do not give any kind of words or symbols. Those products are difficult and even frustrating to use^v. “*The designer should aim for utility, not beauty*”^{vi}

Furthermore as we can see in the results that users understand better those products that meet “*The Core receiver requirements*”. It is an undeniable fact that the users will perform better with products that they already have interact with or objects that their functions are similar to others that they have been using frequently. That’s why they face so much trouble using the remote control 1 which has the “zero” button in an unusual place and the remote control 2 which has two buttons for the same function.

Also consumers cannot remember more than two pre-fixed settings when using a product or a device. The consumer is making some mental models about themselves and the product. The mental model of a device is formed by the actions the potential user thinks that can be done by using it. If this “image” is not clear then there will be difficulties and misunderstandings about the product.^{vii} The actual image of the product should be corresponding to the user’s mental model. That means that the designer has to provide the users with the right directions in order to operate the product and interact with it without difficulties. As a result it is designers job to help the consumer form a flawless mental model in order to understand better the product and don’t have wrong expectations.

Taking into account the abovementioned facts we understand that the designer has to have in mind the features of the pre-existing products and the products that people are accustomed to use and they are familiar with. In our everyday life we face difficulties when a new product or interface replaces the pre-existing one.

The 75+ group mentioned that the most difficult controller to use was the number 3 (the one with the identical button). The problem which arises from this statement is that people can be confused if they will not be provided with correct mappings.

The mappings have to take advantage of physical analogies and pre-existing cultural standards in order to lead in better understanding. Natural mapping leads to immediate understanding and creates sign that it is not going to be forgotten by the user^{viii}.

Of course it is a matter of visibility as we mentioned before. A device is easy to be used when the set of possible actions is visible^{ix}. However there is another aspect that we have to take in mind because of that statement. Every product in order to be

intuitive must be able to be used within minimum of cues. That means that controls can cause trouble if they not placed in the right place and organized well. A simple solution to the organization problem is to set the buttons, switches or whatever cues for one function apart from others that are designed for different functions. Moreover we can use different type of controls. These two solutions can be combined because we minimize the possibility that the user will be confused and will choose the wrong switch.^x

An additional solution in order to provide an intuitive product is to prevent errors, accidents and wrong uses. This method is called “*forcing functions*”. Forcing functions are the *extreme case of strong constraints that make it easy to discover erroneous behavior*.^{xi} Using these techniques the designer can prevent people from undesirable actions, such as pressing the wrong button for the wrong action. In our case the remote control 3, had the same or identical buttons without any sign of explanation or prevention.

No significant differences observed on the aesthetical part. That doesn't mean that the designer should not focus on the aesthetics of the product. Aesthetics is a very important feature but the most critical one is the utility. If a product is just aesthetically pleasing but not intuitive to use then the design will fail.

2.2 DESIGN OF SIMPLIFIED TELEVISION REMOTE CONTROLS: A CASE FOR BEHAVIORAL AND EMOTIONAL USABILITY ^{xii}

The purpose of this study was to create and develop a lot of variations of remote control concepts in order to test the ergonomics, convenience and how enjoyable are to use. The sample was comprised by 147 consumer-users in three different cities.

The results yielded provided information and guidelines about the consumer trends, children and adult desires.

The study conducted taking into consideration the concepts of behavioral usability (refers strictly to the usability of an object) and emotional usability (refers to concepts such as entertainment and factors which contribute to the reinforcement of the user's experience).

The design process assigned to a multidisciplinary design team which created 20 remote concepts. From them 20, only 3 were chosen for more examination.

The first concept known as “*puck*” pointed out the geometric design and the large controls, focusing on usability. The second one – “*shoe*” (*because it reminds a woman’s shoe*) -focuses more on ergonomics as it was created so as to fit better on hand and to provide amenities for the fingers and wrist. The third design, named “*ball*”, created in order to present an alternative way of designing a remote control, a way that the audience was not familiar with.

Subsequently the stage of prototyping and testing was very interesting. Users had a positive opinion about the “*shoe*” concept. It fulfilled its purpose because the users stated that it fits well in every hand. Moreover it was really enjoyable for them to hold it and interact with it. On the other hand the “*ball*” declared as “exciting” because it was a product that they didn’t really expect to be used as a remote control. The “*puck*” did not satisfy the users in the same way the previous remote controls did.

In this survey 147 people participated all above the age of 12, male and women in order to achieve better demographic results. Except that, three other groups of remote controls were examined. The first two groups consisted of fully operational remote controls and the second set comprised of realistic non-operational mockups. The user discussed their preferences and eventually ranked the products taking into account which satisfy them better overall.

Based on this survey the following outcomes were drawn:

The greater number of the users is operating rectilinear controllers and not of the highest standard of quality. Also the survey separated the user in four categories taking into account the way they hold the remote and use the buttons: *finger pushers, thumb pushers, two-hand finger pushers, and tabletop finger pushers.*

The investigation showed that the majority of the users had an inclination on the “*shoe*” concept. At this point we have to state that no significant differences were noticed in preferences based on age, location or gender.

The “*shoe*” concept was described as fitting every kind of people hands, from large men’s to petite women’s. However the “*ball*” in difference with the initial thoughts

did not satisfy the users so much. The second phase of the survey showed that most of the people are accustomed to interact with linear remote controls. So the users were not ready for such a dramatic change in the shape of the object.

2.2.1 Research 2: Discussion and Conclusions

After the analyzing of this particular research a lot of useful conclusions were drawn. As the majority of the consumers use remote controls with similar structure and shape we can understand that people will get bewildered when they will try to understand how to interact with a new product and use it effectively^{xiii}. A new product can be complex, especially when is presented to the market with a lot of variations and forms. As a result the concept of every new product seems inconvenient to the simple user. The design of the product must provide the users with tools that will guide them so as to handle it effortlessly and be comfortable.

People in the survey found out that the ball concept was exciting but it didn't provide the users with the abovementioned amenities. The concept seemed excited at the first glance but the usage was difficult and complex because of a main reason: Lack of familiarity. It is difficult for a consumer to use a completely different object having in mind an absolutely contrasting archetype in mind, the rectangular type of remote control. However this problem can be surpassed by providing comprehensible and understandable signifiers. A signifier is an indicator which urging people to the desirable behavior^{xiv}. Moreover there is another method that we mentioned before and is used to prevent people from wrong and unwanted actions. This method is called "*forcing functions*". Forcing functions in fact is guidance in order to simplify the tasks and direct the user to the required behavior. In conclusion if the designer makes the concept cohesive and well-structured it is possible to create understandable experiences, that people can lean immediately and instill a feeling of familiarity to the user.^{xv}

The "shoe" concept satisfied the majority of people taking part in the survey because it was understandable, easy to use and familiar. As a result all kind of users operated it easily.

On the other side another significant aspect that plays major role in understanding of products is the aesthetical part. Of course creating conceptual models that help people understand the subject is crucial^{xvi}, but the product has to be aesthetically pleasing

too. Appearance matters in electrical devices. A simple and intuitive product can be aesthetically pleasing if the designer organizes its functions properly. In our case, a device that is easily comprehensible and the user can figure out the majority of controls and functions without spending much time, will satisfy the user needs. The organization of the controls, provide all the required information the user needs to know so as to immediately understand which control corresponds to which function^{xvii}. Organization makes a system of many appear fewer^{xviii}. Additionally the visual aspect can satisfy a potential user. Neutral colors, sizes and graphics contribute to a minimal and aesthetically pleasing product.

Furthermore, the embodying of characteristics like better quality materials may contribute to provide a premium for the eyes of the consumer product. It is true that instances of overkill like adding a premium material can satisfy better the consumer^{xix}.

To sum up, complexity in a product arises when the designer does not provide mappings and signifiers and there are conflicts between the conceptual models of the user in relation with the provided concept. Complexity can be prevented by organizing and making the product learnable and comprehensible^{xx}. When the user knows how to use the product and understands the meaning of the context, the process of interaction with the product seems easier.

The designer should think about how the users behave in regular bases in order to provide an ergonomic, aesthetically pleasing and intuitive product. This can be verified by the fact that the product which tried to approach the abovementioned techniques –the “shoe”- satisfied better the audience.

2.3 MINIMALIST AND INTUITIVE USER INTERFACE DESIGN GUIDELINES FOR CONSUMER DEVICES^{xxi}

People use many consumer electronic devices every day. As different manufacturers provide different interfaces for similar tasks, electronic devices have become difficult to use and more complex. This study presents design guidelines which can be applied in CE (Consumer Electronic) devices in order to be more intuitive and understandable to the common user. Everyday users interact with electronic devices using the user

interface (UI). Information searching, responses of the system and containing data is presented through the UI. As a result it should be designed in a way that facilitates the user, being comprehensible and easy to use. Responses of the system should be conceivable and simple.

A lot of these devices are becoming more complex as the corporations add more and more features trying to acquire competitive advantage. The main problem is that similar functions that every product has, regardless the manufacturer, are presented differently, not to mention that sometimes is impossible to operate the product without using the instruction book. The user interface may not be the factor that will be responsible for the commercial success of the product but it is of paramount of importance and differentiates the product from the competitors.

In this paper the researchers created taxonomy of UI dimensions in order to understand better the critical parts of UI design and to identify what design guidelines should be adjusted in order the products to be used.

1. The first dimension is about Physical and Non-Physical interface. Physical interface involves all the tangible features that help the user interact with the object such as buttons, screens and controls. On the other hand Non-Physical interface has to do with all the graphical and other information, like sound, that help user interact with the product.
2. The next dimension refers to the Aesthetics and Emotions. It concerns both the Physical and Non-Physical interface and it is about the visual aspect of the object, the auditory and the tactile.
3. The third dimension is the Convenience. It is one of the most important factors referring to the product usability. Ease of operation and ease of identification of the attributes such as font sizes, colors and shapes are the main factors that being examined.
4. Operating Mechanisms. Of course this dimension concerns the Physical and Non Physical interface. Every device is different and may require different use and handles. For instance a TV remote controller may require an up and down channel button while some other device needs a play/pause switch.
5. The last dimension refers to the organization of information and information content of the Non-Physical user interface. In other words this dimension has

to do with what the user sees and interacts with. Installation (cable connection and settings), representation such as signals, icons, feedback or other visual information and operation tasks of the system like menus, inputs and outputs are some of those functions.

After the analyzing of the dimensions three guidelines which lead to intuitive, simple and easy to use design are presented.

1. Minimum

As the product features are always increasing manufacturers and designers are adding more and more items in the user interface design. The number of them should be kept a low as possible. That means that the designer has to minimize the elements of the interface that the user will interact with.

Firstly the number of physical interaction buttons should be decreased. Functions that are not being used in regular basis or as often as other should be designed for the Non-Physical interface. Moreover it should be avoided the addition of more than two functions in one button. Consumers are used to designs such as “on and off” function to be placed on the same button. As a result adding more functions or creating a menu will confuse the user.

Another aspect of minimal and simple design is the fact that the user has to use the product without consulting the manual. In order to make this possible the designer should create an object with mappings and signifiers that will provide guidance to the user. Signifiers that are not comprehensive and unnecessary have to be converted or adjusted. Mappings do not concern only symbols and icons but menus too. Sentences on both physical and non-physical design elements play a major role in the process of making a function understandable. To make this possible the designer has to use short and to the point phrases.

Last but not least, the menu should be kept brief without huge amount of choices to avoid making the interface difficult to read and use.

2. Intuitiveness

In order people to start not consulting the manual the designers should provide the user with understandable and self-explained symbols, signs and icons Furthermore

specific phrases that engineers or mechanics use should be avoided because the common user is not specialized. Every signifier has to be meaningful and understandable in order to create an intuitive product. In addition to that the designer has to take advantage of the already known knowledge of the users and be alert so as to create objects and functions that people will understand automatically. For example they can use symbols that are well known like the use of “plus” and “minus” button for a volume adjustment control in remotes. As we mentioned before no technical definitions have to be used.

3. Consistency

The products must be intuitive and this can be achieved by consistency too. When an icon or symbol is selected to represent a particular function it should be used throughout the UI. Every day people use many devices either from different or the same manufacturers and we confront with the same problem: Different symbols are used for the same function.

The menu layout, navigations bars and other UI elements should be consistent. Similar or same font style and sizes should be used, not to mention labels that are commonly used in similar actions in our everyday life.

In general vendors should try to be achieved inter-device and intra-device UI consistency.

The last part of the survey is about applying the design guidelines to consumer electronic devices in order demonstrate and then check the value of them in UI design. The names of the companies haven't been mentioned.

1. Nested menu structure (violation of minimum)

As it mentioned before the depth of a menu hierarchy should not surpass the 3 levels. However some digital TV menus in external connection function were 4-level deep.

2. Overlaying of functions (violation of minimum and intuitiveness)

Another aspect that mentioned before is the fact that control, in order to be intuitive should not overlay many functions in one button. The “menu” button on some digital TV's in the survey has more than two functions overlaid on it. Open, close and back.

That means that either the back option should be removed or be used as different function.

3. Hidden functions (violation of intuitiveness)

Lot of digital TV's in the used sample contained the feature "program reservation" in the "program guide" menu. This is a clearly bad design because it is probably going to transfer a wrong message to the users and confuse them. In order the problem to be surpassed, the designer has to change the menu's name, or add the feature to a separate menu.

4. Use of difficult or non-helpful words or phrases (violation of intuitiveness)

Another problem is that a lot of digital TV's and DVD recorders has to do with phrasing and use of technical words. The specialized terminology with sentences like "*free space remaining: 700MB*" should be replaced with common language such a "*x songs can be added*".

5. Mismatch of the PUI and NPUI elements (violation of consistency and minimum)

It is true that if a function in physical-interface is provided by using a switch the user will get confused if the designer depict this function with another way (for example a button) in the non-physical interface.

6. Use of different words, symbols and labels for the same functions within the same devices or across different devices can confuse the users. Inconsistent operating mechanisms within a menu and inconsistent operating mechanisms between similar devices can cause problems in the consistency of the system.

2.3.1 Research 3: Discussion and Conclusions

After analyzing the abovementioned facts we understand that usability and intuitiveness depend on simplicity. Manufacturers and designers should apply the design guidelines that being discussed before in order to achieve comprehensiveness, especially in User Interface Design. In order these guidelines to be applied in design, User interface practitioners should have in mind some design principles which will make the product understandable. The first principle is about visibility. Keeping the user informed about the current status and providing feedback can actually simplify

the process of interaction. However it is important to use language that the common user expects and not specialized definitions that only experienced people know. Moreover as we mentioned before the system must be characterized by consistency, which means that all features should be presented and be described in the same way. Another way to achieve simplicity and convenient use is to provide users with the ability to “undo” unwanted actions such as mistakes. While it is important to provide users with a sense that they can trust the system, the UI designer should not deny from experienced users flexibility. For example a lot of softwares allow consumers to use shortcuts for faster processing and efficient usage. Another very important aspect that designers should have in mind is the fact that every product and every interface they design must offer to the user effective support recognition. It is advantageous for users to act without thinking a lot and use the system easier. Suggestions such as google keyboard dictionary or google search’s ability to maintain previous researches are typical examples. Of course error prevention by designing understandable paths, help and documentation by providing comprehensive and to the point help is crucial aspects of good design too. The last principle refers to the aesthetic part. Minimal design makes a user interface look simpler and easier to use. The information being shown can be classified and presented by taking advantage of the clever use of whitespace. As a result a clear and comprehensible interface is going to be introduced.^{xxii} Aesthetics, as it mentioned before, is a very important aspect of user interface design. Removing redundant factors that may confuse the user is improving the experience of interaction with the system.^{xxiii} People prefer aesthetically pleasing products because they seem simpler. That happens because in such products it is easier to understand the functions and easier to remember how they work^{xxiv}. Not to mention that first testing would be enjoyable and leave some good impressions to the potential customer. Besides aesthetics organization makes a system of many functions appear simple and intuitive^{xxv}. Except of space allocation prioritizing of important functions and comprehensible labeling is a critical step to make the user feel that interaction is going to happen without problems and frustrations.

One way to organize better a system is by adding structure consisted by sections and modules. Each section has to be manageable and easy to learn^{xxvi}. As a result the consumer will not overwhelmed by a vast amount of information. Dividing the system

into small parts the designer provides the user with the ability to surpass the complexity.

Consequently if the user do not confront with difficulties it is undeniable that the operation of the product will happen faster. *Reducing time spent feels like simplicity (Maeda 2005)*. Nonetheless we should have in mind that sometimes complexity is unavoidable. Some things can be complicated requiring some knowledge in order to be used efficiently. That does not mean that the user cannot understand and learn a product with such functions, as long as the design is not poor and perplexing^{xxvii}. *Consumer also do not mind complexity if it seems appropriate and necessary. (Norman 2011)*.

The abovementioned factors will lead to a minimal, consistent and intuitive system, taming the complexity; facilitate the user-user interface interaction and providing coherent feedback.

3. Competitive Market analysis and Opportunity Identification

3.1 Competitive Products

Taking into consideration the previous academic research results and conclusions it is an undeniable fact that web and physical analysis is required in order to examine the existing products and their attributes.

A very common used product is the Logitech Harmony Companion. “Companion” is a universal remote control which provides the user with the ability to use many devices, let alone TV, using either the product itself or the smartphone app. Moreover the activity-based buttons designed for easier one-click function operations such as opening Satellite TV or Netflix programs.



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Scheme 1: Logitech Harmony Companion

On the other side customer reviews either written on marketplaces' sites or on videos published on internet platforms such as YouTube implied that there are some very frustrating problems. As we mentioned before a product and especially an electrical device in order to be intuitive for human use it has to be able to be used in the dark. However the remote is not backlit. That means that the buttons do not get lighted in the dark making the operation of the device difficult. The previous academic research showed that visibility is one of the most important values in product design. The important aspects of a product should be visible and clearly marked in order to make it easy to use. Signifiers and signals must provide guidance to the users especially in crucial parts like the buttons in our case. Light is a very important guideline that informs people and force them to the desired behavior.

In addition to that the examination of the –enormous- manual showed that the remote has three buttons (as we can see on the picture) in the upper part but they support more than six activities. Adding lot of functions in one button makes the system complex. The user is not in position to remember lengthy sequences of required steps.^{xxx}Not to mention the fact that the button is represented by musical notes. This is clearly wrong labelling because the functions that can be activated do not refer only to music. For adding extra activities the user has to use the app but customer reviews stated that the app is not useful compared to a physical remote. That happens because of the lack of feedback. A common app on a smartphone can't provide the user with immediate feedback of each action and obviously this will affect the operation process. When there is good feedback the system is understandable. The results are sensible, no arbitrary and meaningful^{xxxi}. Besides that the use of the application requires an Android or iOS device and also internet connection, which means that many users that do not own these can't use it.

A positive aspect that we have to mention at this point is that the remote control has the play-pause-forward-rewind button in a position which leads to easier thumb reach. Another common used controller according to the users is the Logitech Harmony 650.



xxxii

Scheme 2: Logitech Harmony 650

As we can observe in the picture the remote control is roughly divided in three segments. In the first section we can see that a color LCD 1x1 inch is placed. However it is not a touch screen. The control buttons have to be used in order to operate the screen functions. The remote is web programmable, compatible with

Windows or Apple's Mac personal computers. Overall seems well designed and ergonomic, because of that small curve that makes it fit better in hand but many customers stated some problems.

The examination of customer reviews in amazon's electronic marketplace drawn some interesting conclusions.

Many customers stated that despite the fact that the remote is easy to be programmed it takes too much time to operate and power on the devices, either TV or Satellite box. In order to provide simplicity a device should minimize the waiting times. *Saving time feels like simplicity* (Maeda 2005). Of course reducing time means that people can spend it on something else while waiting is frustrating^{xxxiii}.

Another problem that users point out is the fact that it couldn't save the preferences of people using it. For example a customer stated that *"TV was much louder than the previous night^{xxxiv}"* and it *"seems like forever"* when he or she had to add preferences again. It is an undeniable fact that if the user has to do same processes again and again the whole procedure becomes complex and difficult. At this point we have to mention that the users also point out a problem with the reset function. They said that some changes in order to actually work the remote control had to be rebooted. Again we understand that the waiting problem came up again. A customer review stated how frustrating is to wait. Specifically he/she said *"if I had the patience to reboot every time I wanted to sync new changes, it would sort have work"*.

As a result we totally understand that in order to provide an intuitive for human use product designers have to reduce waiting times and provide simple and non-repetitive actions. In addition to that there are some feedback problems too. Some customer reviews talked about problems with handling of the device. They mentioned that while they trying to turn up the volume, a quick tap sometimes raised the volume too much. Another problem related to controls feedback was the fact that buttons where characterized as non-stable. A customer stated: *"I could never get to the point where I was sure a button would engage after I pressed it"*. The lack of feedback causes anxiety. Questions like *"did I really press the button"* or *"how hard do I have to press the button in order to do the function"* are frustrating for the user. Proper feedback removes this kind of stressful feelings. Feedback is explanation of what is happening

in the system and why^{xxxv}. Every feature of the product should provide efficient feedback.

Last but not least, many users indicate problems with the instruction manual. In spite of the fact that Help functionality was characterized as simple and effective the manual was outdated in relation with the system. Wrong or bad instructions fail to provide effective guidance to the users and do not help in troubleshooting. Simple design does not require instructions.

Last but not least it is important to mention and examine the Apple Remote, as Apple is one company reputed for simple, minimal and aesthetic design of its products.



Scheme 3: The Apple Remote^{xxxvi}

The Apple Remote is a simple and minimal device without many buttons as the previous examined controllers. It seems understandable and easy to use. The design is slick and futuristic while the combinations of black and white colors provide the feel of a premium product. However customer reviews in Apple's site seem to disagree with what it mentioned before.

The size of the control gives a lot of trouble to the users. Many customers stated problems like losing among pillows or can't find it when they want to. As usual Apple tried to provide an aesthetically pleasing product but as we can understand they rated design over functionality and usability. Of course people appreciate beautiful in the eye and nice to have products but nothing of that will matter if the product won't work properly. Designers should provide aesthetic products having in mind that the whole system is a unity and everything should work well without diminishing other functions. The product is too short and slippery that a lot people feel that it is not ergonomic not to mention that sometimes is impossible to use in the dark. Trade-offs between aesthetics and functionality is good to happen in order to provide user friendly products. The designer should aim for utility, not beauty^{xxxvii}.

Additionally lots of people stated that by removing buttons it was more difficult to use the product. The main purpose of simplicity is not to remove buttons but to organize them in a way that they are not complex to use. As we mentioned before the user needs signifiers and labelling. This remote does not have any signal of how to operate it. Another aspect that is important is the fact that users feel that the product is not comprehensive. *"You cannot fast-forward easily or back obviously and sometimes it does not respond^{xxxviii}"*. In order a product to be intuitive the interaction process should happen smoothly. Feedback must be given to the user in order to understand the system better.

By the examination of the Apple remote we can understand that an aesthetically pleasing product is not enough to satisfy customer needs. The product has to provide all the above mentioned factors so as to be comprehensible.

3.2 Market Opportunity

Taking into account the user's reviews, in the competitive product analysis part, it is clear that there is a gap in the market for an intuitive remote control. The frustration of so many people according to difficult functions on the devices, not efficient feedback provided and wrong labeling enhances the need of developing an innovative solution for this particular market. In order this to happen trade-offs are to be made correctly taking into consideration the abovementioned factors.

4. Identifying customer needs

The purpose of the above analysis is to identify the potential customer's needs. Therefore a specific process which is consisted by well-grounded steps and conclusions should be organized. The main idea behind this process is to facilitate the user's experience. In other words the basic need is the creation of a self-explanatory product. Visible cues and signals that naturally indicate the user to the desirable actions should be provided. It is also substantial for products and especially in electronic devices to be used without visual contact. In addition to that it is important for the user to handle the product effectively. Ergonomics should be taken into consideration in order to assist those functions. Moreover it is mandatory for a product to inform the user about the current status providing relevant feedback.

5. Establish Target Specifications

- Provide a product with visible clues, use comprehensible indications and signals. It should be used in the dark without the need of visual approach.
- Keep informed the users via coherent feedback. Feedback is the explanation of what is happening to the system. The system should support the user with understandable and to the point help.
- Provide natural mappings for immediate understanding, taking into account physical analogies or familiar for the user signifiers. Right labelling and self-explanatory symbols will make the product simpler.
- Constraints and affordances will also have to be used so as to “force” the user to the desirable behavior. Error prevention and the ability to “undo” an action have to be provided too.
- The product has to be well structured and organized. The set of buttons, switches or other cues have to be comprehensible, minimizing the possibility that the user will be confused. Organized functions lead to comprehensiveness and intuitiveness. Additionally will help in the prioritization of the important controls by the user.
- The remote control should be ergonomic. That means convenient use without the need of stretching in order to reach the desired button.

- Non-repetitive actions have to be made. Saving the preferences will provide the ability to save in time by not setting the same settings more than once. Saving time and not spending it on actions that seem unneeded feels like simplicity.
- The system has to be consistent. That means that similar functions should be presented with the same icon, font or color.
- The remote control has to be aesthetically pleasing taking advantage of the whitespace and using neutral colors. The elements of the interface should be minimized. Too many buttons lead to complexity.
- Common language that every user understands should be used.

6. Design Brief

Project Name: Intuitive for human use Remote Control

Objectives: The main purpose is to improve on a TV remote control making it comprehensible and easy to use. In order this to happen it is mandatory to understand the user needs and follow the laws of simplicity. Moreover complexity of every day products has to be tamed so as to provide an unobtrusive remote control which is not only aesthetically pleasing and minimal but also functional. Ergonomics have to be taken into consideration too.

- Provide indicators and signals for every function, with natural mappings and comprehensible affordances
- Every function has to provide coherent feedback
- The system should be organized based on functions importance or usage frequency in order to be understandable
- It should facilitate the user and be ergonomic. Button size and shape have to lead in intuitive use even in the dark
- Interface elements should be kept to minimum
- Aesthetically pleasing design using neutral color
- Not specialized language should be used. The signifiers have to be understandable for any user.

Target Audience: The remote control has to be understandable and simple for human use. Is expected to be used by a very wide target group, including elders, children, and people with deficiencies such as vision problems and users with little experience in electronic devices.

- The product should consider about people with visual dexterity. Right size lettering, shape and comprehensive texture have to be taken into consideration. Identical buttons for different functions have to be avoided.
- Grouping and positioning of the buttons play major role in comprehensiveness by any user. Especially for those with not much experience.
- One click functions for frequently will help the users achieve the desire action

Materials: The remote control should be eco-friendly, recyclable and safe to use.

- Bioplastics are plastics which come from food waste, vegetable fats and oils, corn and other renewable sources^{xxxix}. Bioplastics (biodegradable plastics) are polymeric materials that can be decomposed into carbon dioxide, water, inorganic compounds or biomass contributing to sustainability and reducing the environmental impact. Recycling, incineration with energy recovery and landfill are some the waste management options for the bioplastic.^{xl}

Look and Feel: It could provide the user with the opportunity to operate the TV system intuitive even at night. The remote control should not be overdesigned but discreet using neutral color in order to match with any king of living room.

- Aesthetically pleasing design
- Taking advantage of the whitespace
- The buttons should be backlit
- Buttons that are not being used frequently should be eliminated

Packaging Design: Should be aesthetic, making the product stands out. It has to be 100% friendly.

- Packaging waste should also concern environmental friendly design. In today's packaging applications many non-biodegradable materials are being used. The remote control's package will be either made out of carton or biodegradable plastic.

7. Concept Generation

It is an undeniable fact that most of people recognize the remote control as a television accessory. In the meantime most of the manufacturers make great efforts to improve on the television functions, forgetting about the remote. As it is examined in the competitive market analysis part most of the users expressed their frustrations about the structure of most of the controls. Therefore it is demanding to overwhelm the drawbacks of the “typical” remote control.

Some of the common problems that are mentioned before concern the feedback provided by the device, the mappings and signifiers for the possible functions, the time of button recognition and the ergonomics.

As a consequence the aim of this study is to surpass those worries and also to introduce a television remote control that can be identified as an independent product.

7.1 First Thoughts and Sketching

The main goal is to design a simple product, intuitive for human use. In order to make this concept possible the remote should be comprised only by the main controls and the most used functions. The research part and the surveys analyzed before made clear that most of the people focused on specific tasks when they watching television and use their controllers. In addition to that customer reviews that being studied showed the importance of focusing functions that will facilitate the user.

As a result it is preferred to present a product that will not confuse the user with extra applications that only the experienced user will understand. The purpose is the accommodation of all people and especially the inexperienced or those with dexterities.

7.1.1 Concept 0

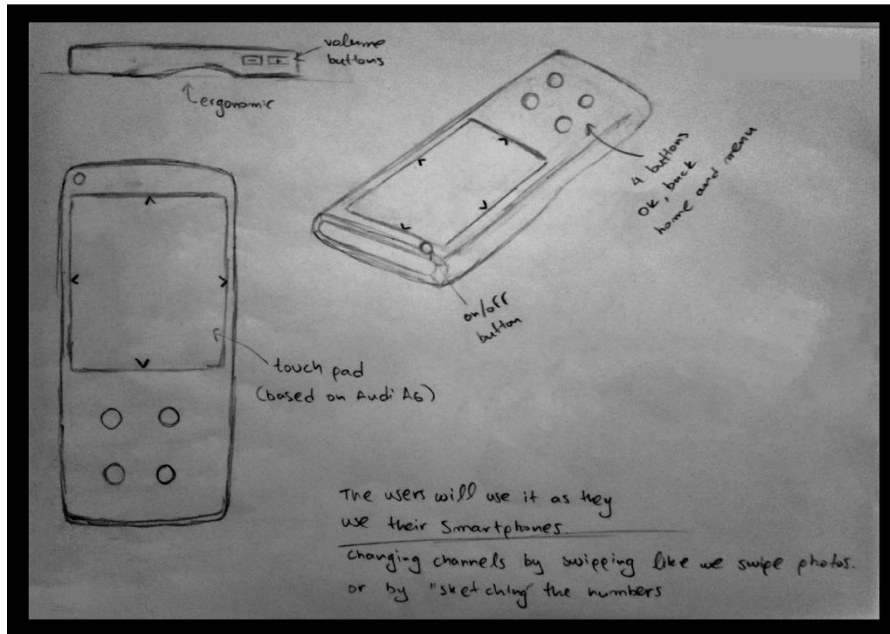


figure 1

The addition of the touchpad makes the products easier to use, especially at night not to mention the fact that most of the people daily use touchpads in electronic devices. The users will operate it like they operate their smartphones, swiping left or right in the touchpad. Additionally, only four button were added (ok, back, home and menu) in an attempt to get rid of the non-making sense button that most of the controller contain.

However three crucial problems aroused. Despite the fact that the product contains the touchpad, which facilitates the operation, the user has to remind and get used to the interface. Moreover there is a problem with the signifiers. In the analysis part it mentioned that every product in order to be intuitive has to contain mappings that help the user recognize the functions at no time. However the buttons in this concept are identical and no labelling was added.

The second problem concerns the ergonomics. In spite of the slight curve in the back of the control, it is not possible to make fit in every users palm. The target audience involves a wide range of people. That means kids, adults and of course elders. Consequently ergonomics should be taken into account.

The last problem is that the product is not possible to be recognized as an independent product. Its shape and interface will always reminds to the user that it is a television accessory.

7.1.2 Concept Generation Process and Inspiration

It is true that when people refer to a television remote control the place that comes in mind is the living room. Taking into account that most of televisions are located there the main notion is to design a product that will be discreet and combine the characteristic that mentioned previously.

Therefore a research on elements of living room has been made, containing furniture, gadgets and light design. Products and designs like these not only helped in the experiment of the initial shape of the product but also made clear that it is important to think the remote control as an different entity.

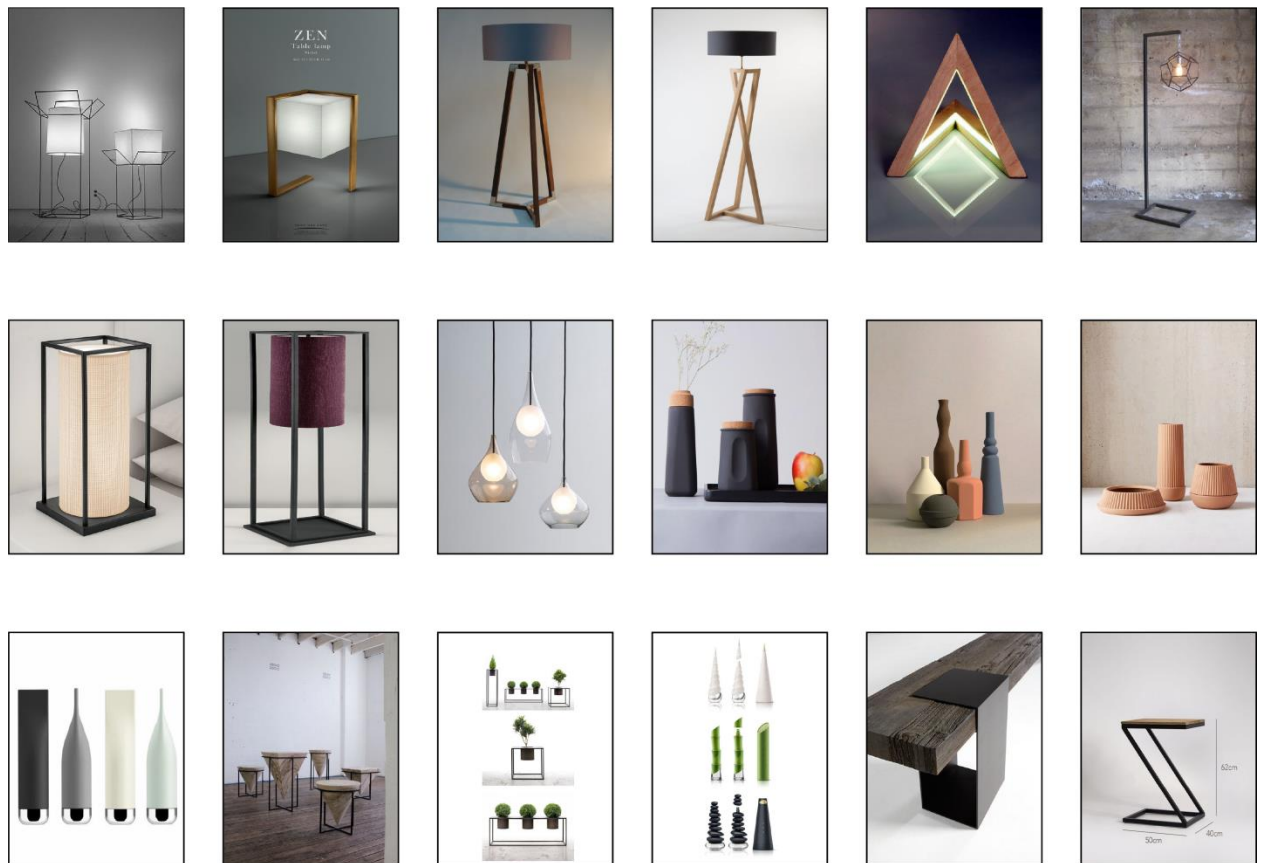


figure 2

7.1.3 Sketching

At the first stages of the process it was made clear that the remote control should combine features that facilitate the user. The shape of the product is an important part of this aspiration. Apart from the shape, in order the remote control to be identified as an autonomous product another aspect should be added. As the pictures above present, lots of products contain pedestals or stands. So it would be an important aspect for the product to have a base in order to differentiate from the competitive products.

A lot of sketch variations are introduced in the picture below. Bases, stands and ways of use are presented too. The main idea of every sketch is to eliminate the extra buttons and to design an aesthetically pleasing, simple remote control.

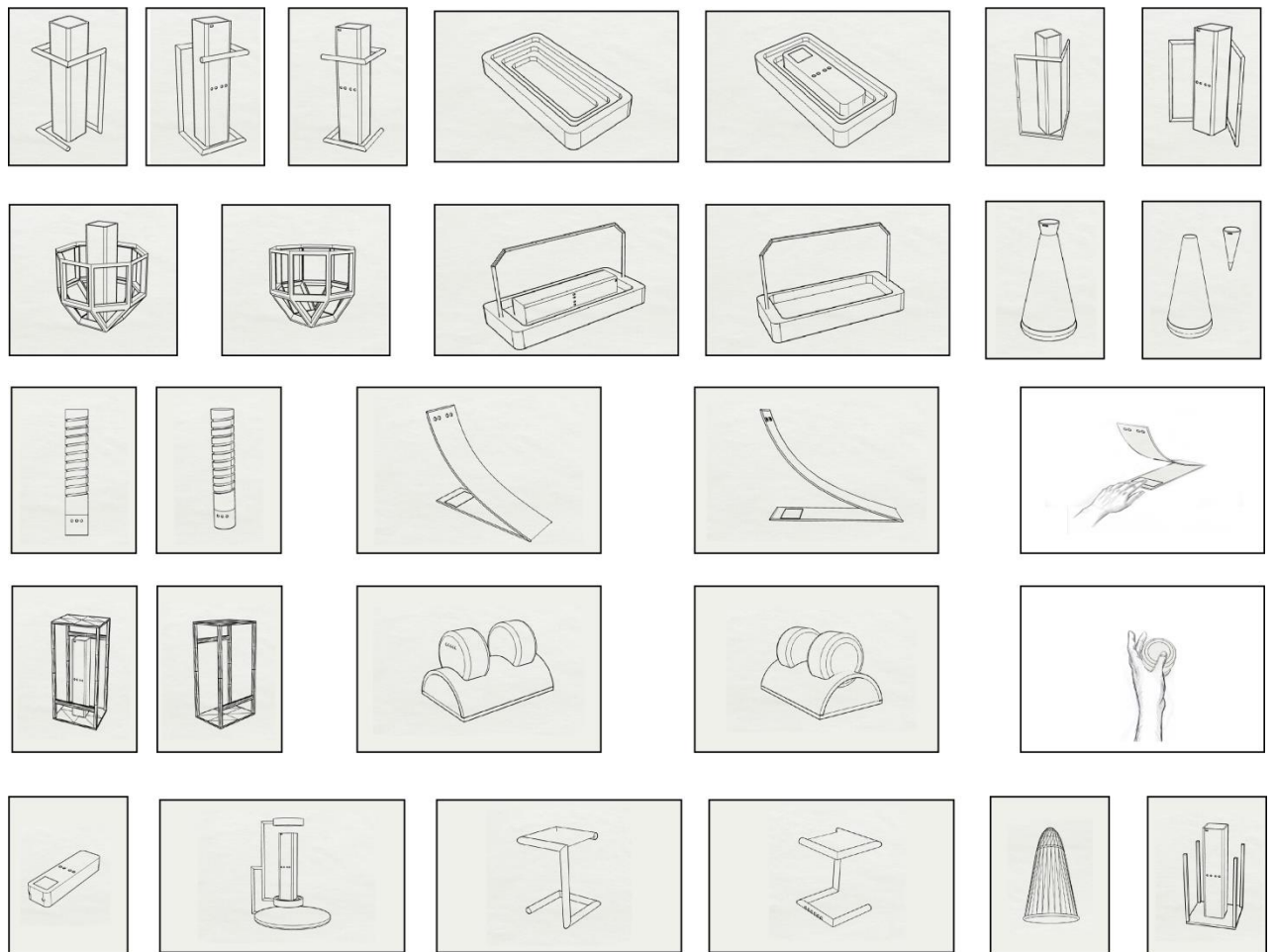


figure 3

8. Concept(s) Selection

Concept(s) selection is an essential stage of the process. The decision about the concepts that are the best for further development is going to be made. Desirable characteristics, possible attributes of the product and customer needs have to be taken into consideration. These criteria are crucial for the additional development of the product as it mentioned in the analysis phase. Advantages and drawbacks of every concept have to be evaluated. Also prototyping is vital too.

It mentioned in the early stages of the whole process that the remote control has to introduce some specific attributes. Simple and aesthetically pleasing design is the first characteristic that should be taken into account. Inexperienced users and people with dexterities must not be confused with the product elements. A consistent product with as few as possible buttons will lead to immediate understanding.

Another very important aspect that should be studied is the ergonomics. Hand operated devices demand the investigation of elements such as thumb reaching distances, hand's length and breadth or even the hand's circumference. Moreover simple and intuitive operation requests efficient button labelling and coherent feedback in order to accommodate operation without visual contact.

Lastly, there are two important characteristics that the users stated in their reviews that studied in the research analysis. It also became known from the users the aspiration to use the product in multiple ways. To be more specific many reviews concerned about the ability of product customization. In addition to that people seemed to admire products that combine something new and radical, but combining it with some already known function.

Bearing in mind all the above mentioned factors, two basic concepts are supposed to be added to the final product. The first concerns the volume adjusting and the channel changing and is the addition of a touchpad. It mentioned before the value of the familiarity in products. It is an undeniable fact that most of the people are familiar with this technology and they use it in daily basis. On the other hand the second concept is the integration of a voice assistant to the control. Today's technology has introduced products with voice control and they are well-known to the public. Moreover it applies on the customization part. The user will have the ability to choose

how they would like to operate the device, either via the touchpad or via voice control.

8.2 First models and Prototyping

The first model that fulfills the prerequisites theory is presented in the picture below:

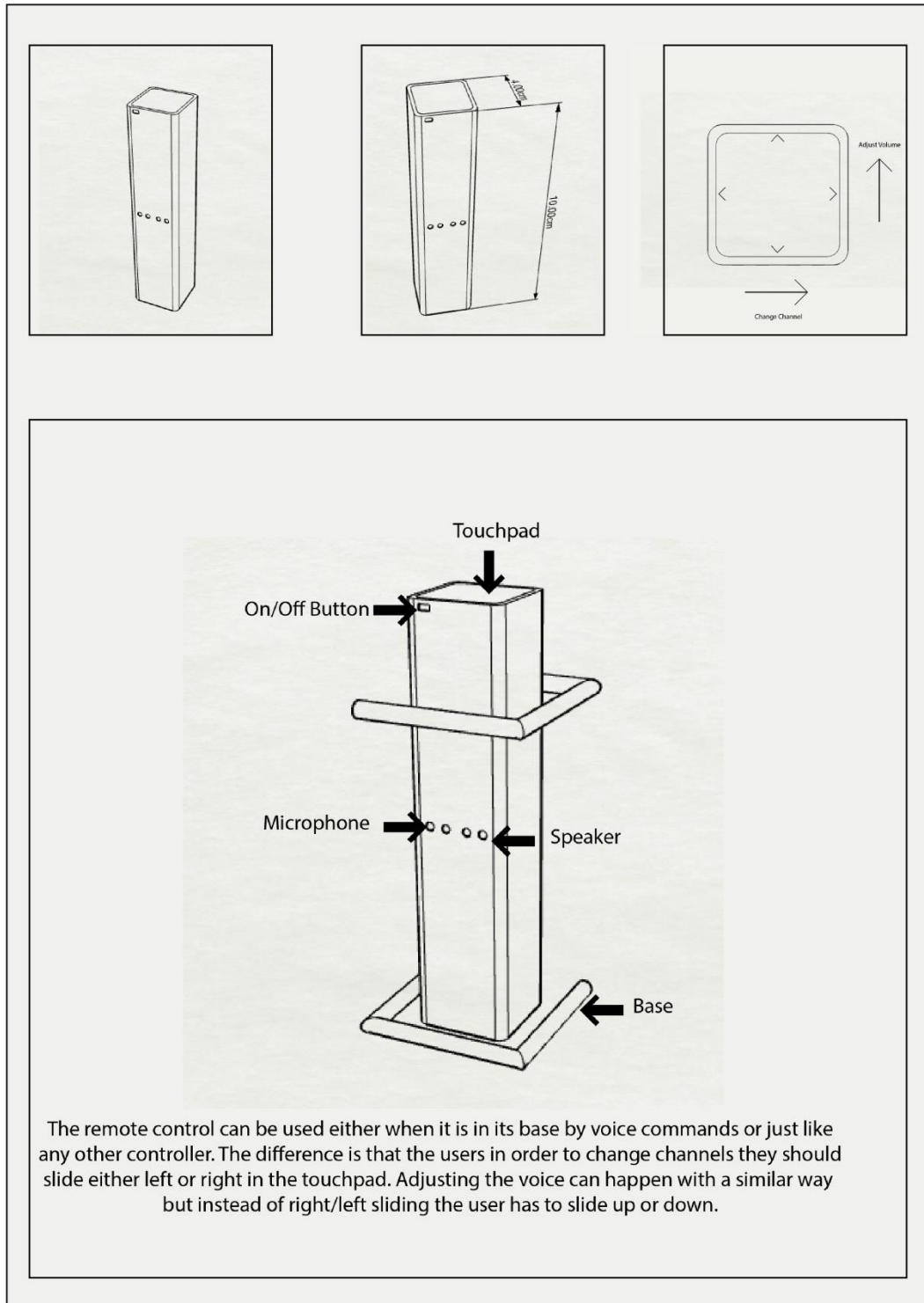


figure 4

The remote control can be operated depended on the users' preferences. The touchpad offers the ability for easier channel changing and volume adjustment while the voice control facilitates the remote use of the controller.

The following product is the second variation, works with the same way and is presented in this early stage of the design process in the picture below:

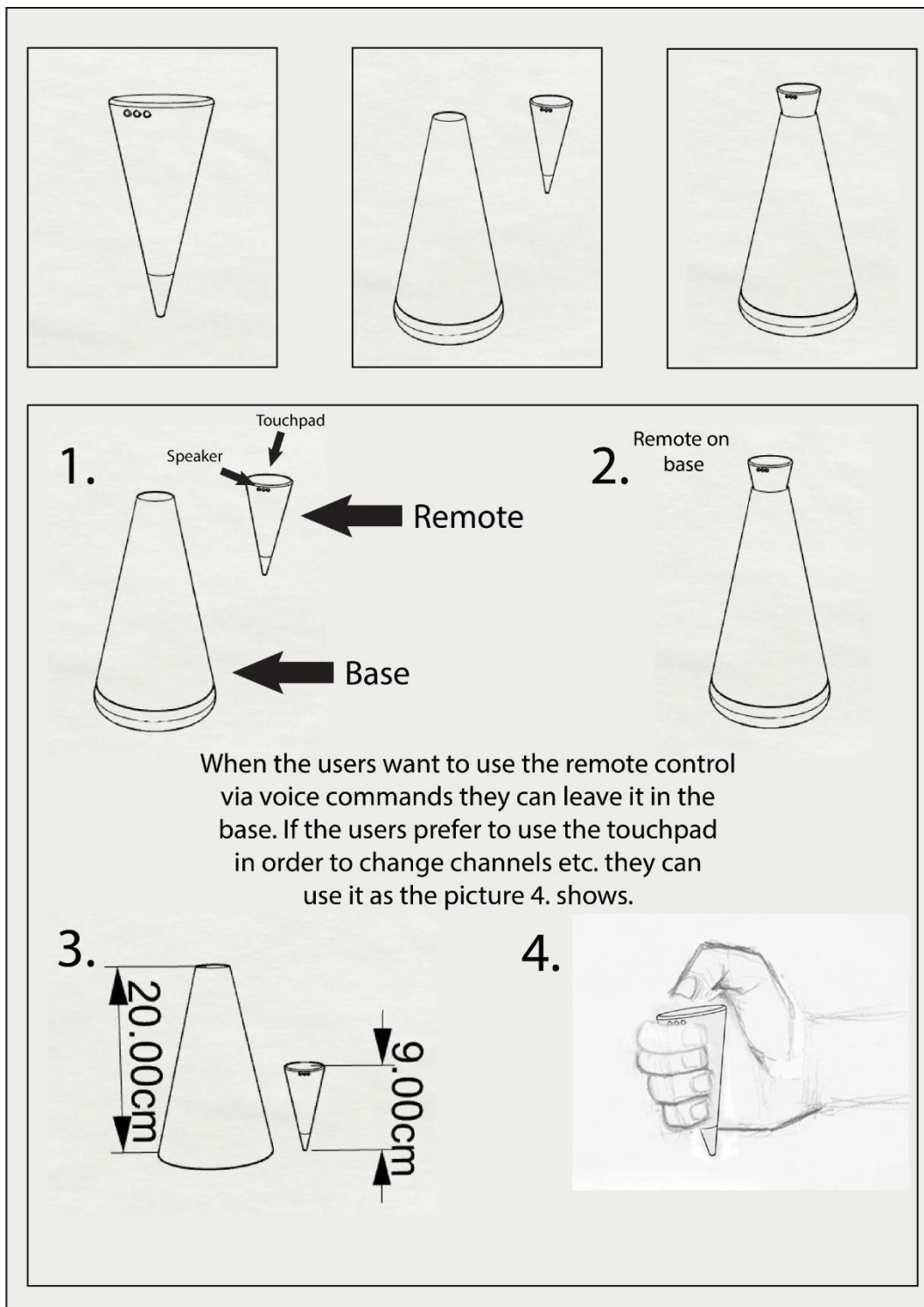
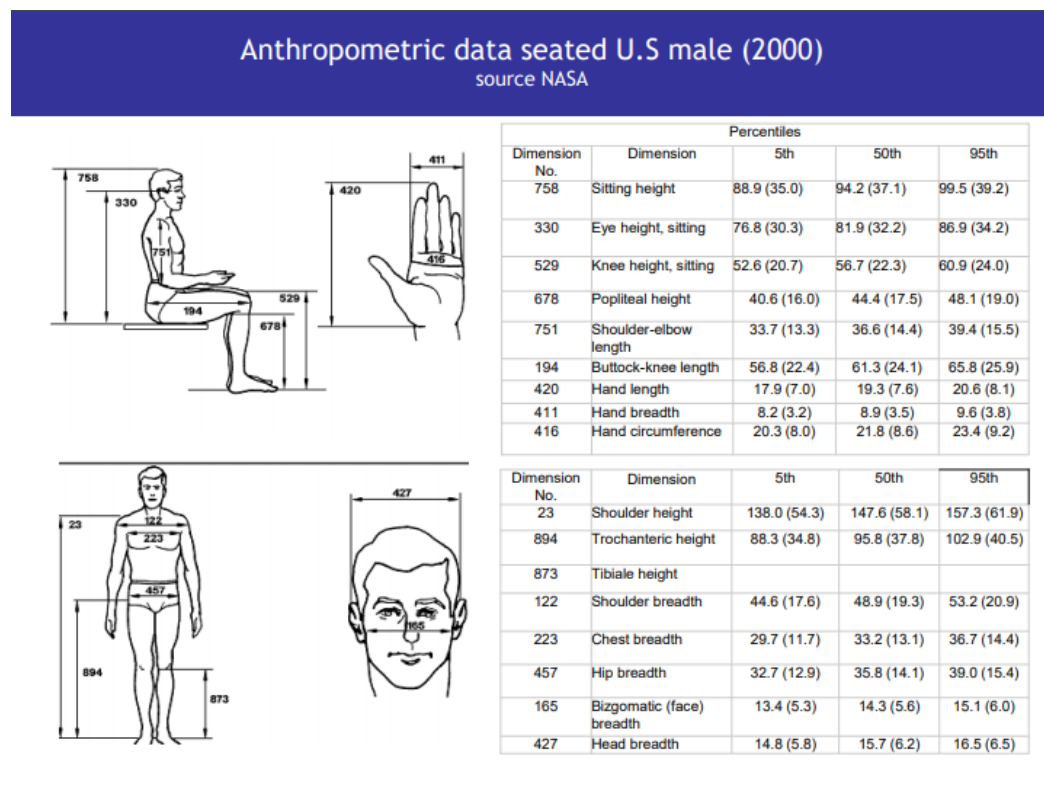


figure 5

8.2.1 Ergonomics

Human factors and ergonomics, is the application of psychological and physiological principles to the engineering and design of products, processes, and systems.^{xli} In other words ergonomics focuses on the interaction of human with products, tools, devices, equipment and processes in their daily life. The design of everyday products such as the remote control demands this kind of study in order to make them compatible with needs and desires, taking also into account limitations and difficulties. The main concern is to achieve trade-offs between performance, convenience, efficiency and system productivity. Additionally shaping and interface elements have to be studied too.

As a consequence in order to proceed to the first prototyping phase anthropometrics had to be taken into consideration.



Base on the data above, as the design concerns a handheld device the dimensions about hand length, hand breadth and hand circumference are considered in order to help to design a remote control which fits in every type of hand.

It is needed to design a device which can be used by wide range of users from kids to adults. Taking into consideration the anthropometrics board it is preferable to design

the remote control with the dimensions shown below. As the design should be applied even to the smallest hand, which is represented by the 5% in the board, hand breadth dimension (411) has to be taken into account. That means 8.2cm. However the product should be bigger than hand breadth, therefore it is suggested 10cm height.

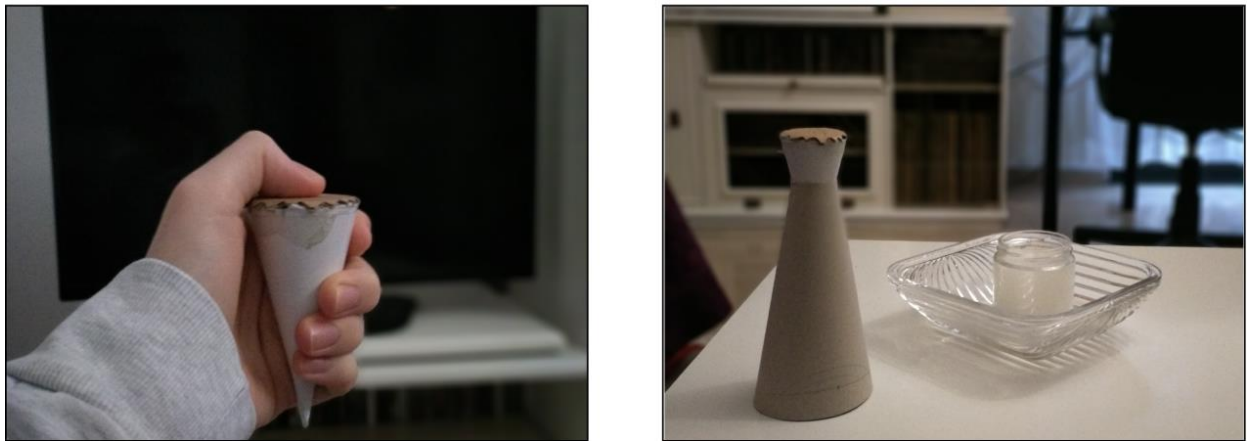
8.2.2 Prototyping

No one can deny the fact that ideas and concepts may diverge from the real product. The solution to this problem is the creation of prototypes. In this process aspects and characteristics can be reconsidered for improvement or refusing. It is also possible to test product ergonomics which in this case, as we talk about a hand operated device, is very important. Additionally interface elements may be added so as to present a first version of the product. It is better to recognize any difficulties and problem early in the development process and also provide to the potential users an actual product – working or not- in order to share their opinions about it.



1.

Figure 6 - Carton prototype of the first concept



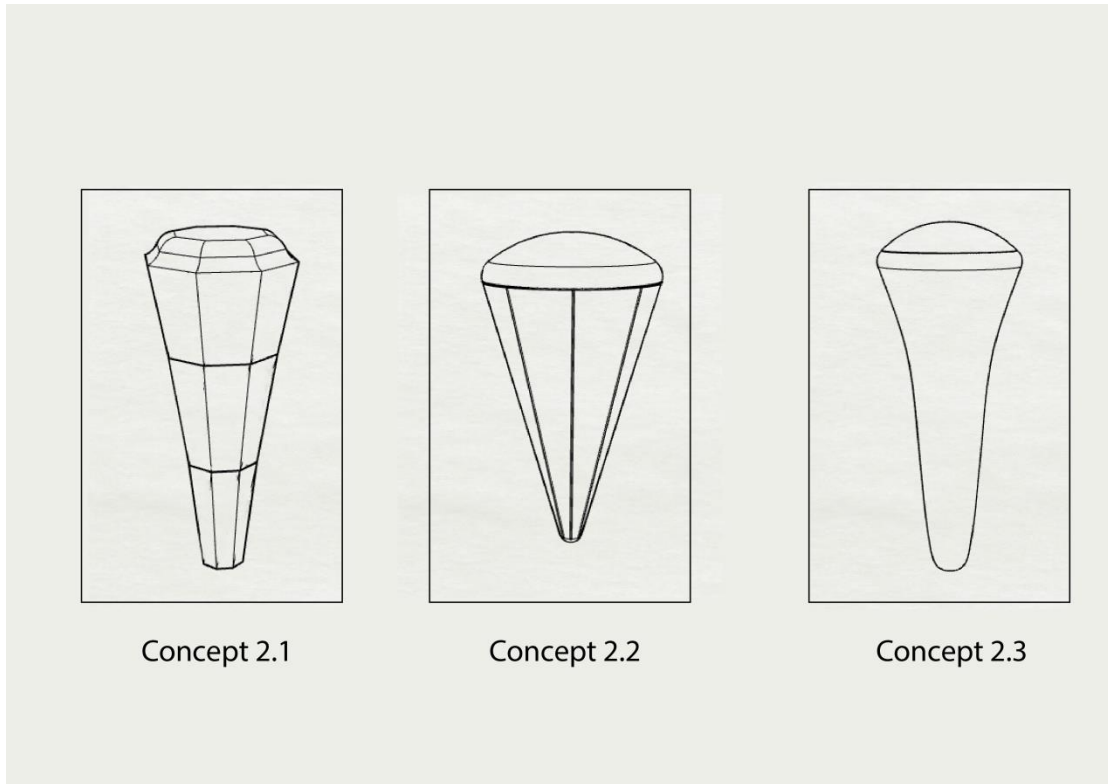
2.

Figure 7 – Carton Prototype of the second concept

9. Further Development

After the early prototyping phase further development of the selected concept is required. Based on the previous mentioned attributes and the customer needs that studied before the concept that seems to match with the design brief requirements is the second one. In addition to that the shape and the base diverse it from the typical television remote controls and as result it is not recognized as a television accessory.

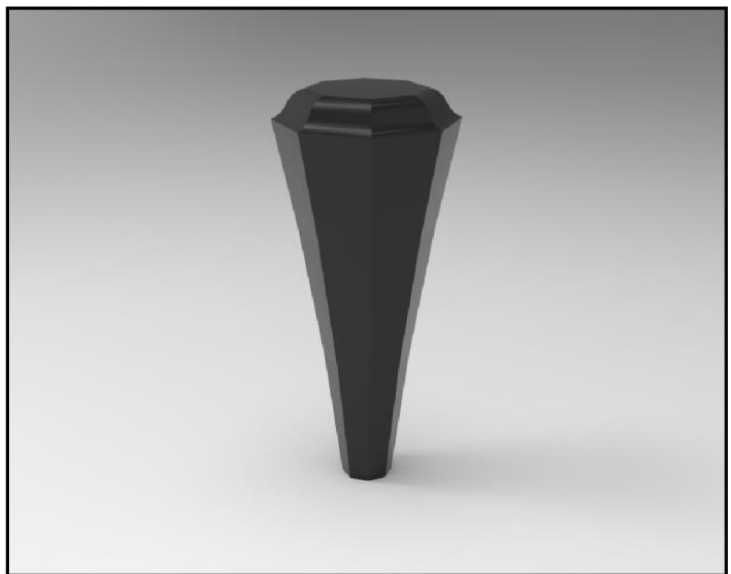
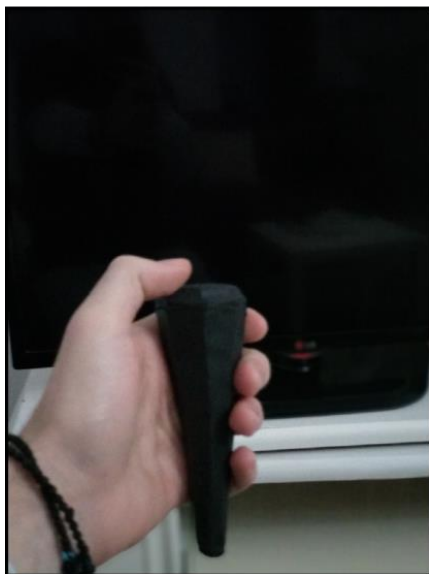
However in order to design a product for the user testing it is mandatory to develop further the concept. More sketches have been drawn and eventually another three basic concepts are suggested based on the cone-shape design.

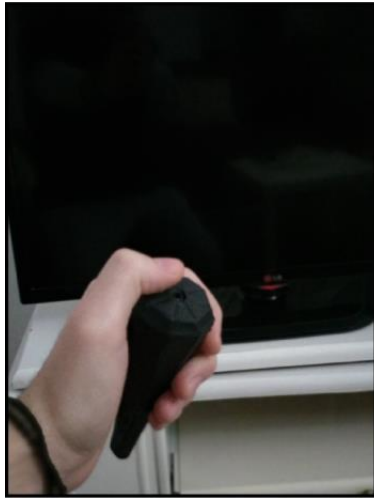


All of the three concepts had to be prototyped again in order to spot the advantages and drawbacks in order to improve on the best one. However a material which will represent better the product has to be used for the modelling.

9.1 Plasticine Prototypes

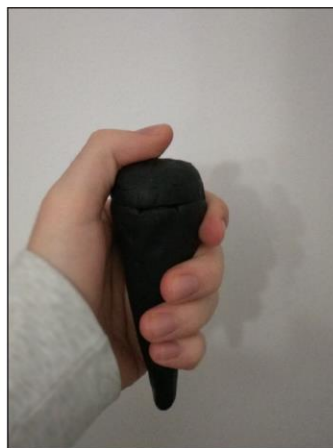
9.1.1 Concept 2.1





There is a great argument concerning this remote control. On the one hand the design is aesthetically pleasing. However on the other side the “geometrical” shape seems to prevent the “perfect” fitting.

9.1.2 Concept 2.2



The rounded top of the remote control makes easier for the thumb to reach the desirable spots on the touchpad. The main concern is about the other part which seems a little bit thick and does not provide suitable holding.

9.1.3 Concept 2.3



This control fit to the hand in the best way in comparison with the others. The smaller rounded top helps the user to achieve easy movement of the thumb. The other part is getting slimmer and follows the hand “shape”.

10. User Testing

High user satisfaction requires understanding of the potential customers. It is very important to recognize if people like the product and its functions and what are their concerns.

The only way to understand what the advantages and the disadvantages of the product being designed are is to talk to the users and let them interact with the product.

Gathering data from potential customers is the only way to acquire as much knowledge as possible in order to improve on the design and the functions. The main concern is to create a new product that helps people achieve their purposes, get maximum value of it and reduce their problems.

In the case of the remote control five different people were asked to use and test the remote control prototype. The first phase of the research conducted using a plasticine prototype.

10.1 User Testing – Phase 1

User No1



Male, Age 25 (Height 1.91)

The user stated that the product's shape is unexpected for a television remote control. However it reminded him the joysticks people used to use for electronic gaming devices or personal computers. However he stated that the control's shape should be more rounded in the transition from the top part to the rest of the product. No slippery issues were stated.



Concerning the touchpad the fact that the thumb reaches easily the desirable positions was a positive experience for him. His opinion about the on/off button was that it should be placed in order to be easy to be reach from the index finger.



User No2



Female, Age 55 (Height 1.68)

The user stated that the product's shape is following the hand's shape and as a result it has ergonomic handle. Despite the fact that the user found easy the movement in order to change channel, she stated that the volume adjusting part seems like an unusual move.



Concerning the touchpad part the user stated that the top part is a little bit more rounded than the expected.



The user also stated some thoughts about the on/off button. She told me that it should be placed in way that it is easy to reach it without moving the thumb.

User No3



Male, Age 24 (Height 1,85)

User number 3 found the product very ergonomic as he stated that it follows hand shape. However he also stated that the remote contain a material that will help the better holding and handling. He stated that “*my current TV controller slips from my hand all time*”.

Moreover he stated that the remote control is “*easy to understand*” because it is not comprised by many buttons and it can be used “*without even looking at it*”.



Concerning the touchpad the movements remind him the way we swipe the through smartphones and found it really easy. He also stated, like the previous user, the fact that the on/off button should be placed somewhere where is easy for the forefinger to reach it.

User No4



Male, Age 66 (Height 1.78)

The user stated that this product is very unusual for a remote control. Questions like how the product is going to change the channels, or how it will aim to the television were asked. It is clear that signifiers are mandatory for the users.

On the other side the user stated that the control is ergonomic and fits well in the hand



Concerning the touchpad, we can understand again how important the signifiers are. The user did not understand that the top of the controller is a touchpad. He believed that it was comprised by four buttons in spite of the fact that he uses a laptop touchpad every day, as he stated. He liked the idea though.

Last but not least, when it was clear to him how the controller is going to be used he stated that maybe the product is bigger than it should be.

User No5



Female, Age 27 (Height 1.70)

The user stated that the controller fits well in the hand. She found out easily how the product works without any help and she liked the idea of a touchpad because, as she established, “*more or less everyone uses a touchpad in their everyday life*”. However she asked how the changing of channel/adjusting the volume is going to happen because the prototype did not contain any signs. She also had some questions concerning the materials and if the product is going to be slippery.

About the on/off button she also stated that adding it to a point which the forefinger will touch it easily would be great.

10.2 Phase 1 – Conclusions

After the user testing phase the analyzation of the feedback provided by the sample is mandatory. Almost every user stated the fact that the on/off button should be placed in a position that is easy to be reached by the index finger. As a result it should be a regular on/off button placed on the upper part of the control, but not on the top.

Concerning the shape we can understand that the users were happy with the current shape and only some adjustments should be done, making the product smoother in the transition of the top part to the rest of the product. Moreover the remote control should be a little thinner so the users can reach easier all the touchpad features.

The addition of signifiers is mandatory as some user asked how the product works. The touchpad should be understandable and not confusing to the users.

Last but not least as many users concern about the fact that the product maybe would be slippery, the addition of some rubber material is considered.

10.3 User Testing – Phase 2

After the user statements considered appropriate to remake the prototype taking into consideration the suggestions that established before. However this time the material used was clay in order to represent the product in a better and more stable way. In addition to that graphics were added so as to be easier for the user to understand the functions.

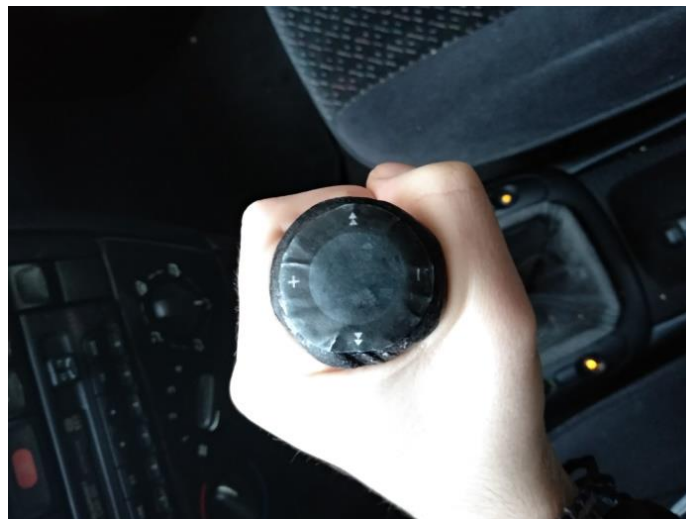
User No1

Male, Age 25 (Height 1.91)

The user stated that the shape still reminds him an electronic device joystick but the addition of the signifiers *“explains what the product is about”*.

He like the fact that the product became thinner because *“now is more elegant”*. Concerning the interface he stated that he wouldn't change something because now the product is self-explanatory and *“does not even require a manual”*.

On/off button was easy to reach but he stated that he will definitely press it by accident due to the fact that *“he has big hands”*.



User No2



Female, Age 55 (Height 1.68)

The user stated that the product's shape is now thinner and as a result it helps not the position of the button to the top, but also the holding of the control.



In addition to that she stated that the position of the on/off button is making it easy for the user to reach it. The interesting part of that statement was the fact that she established that maybe the user will hit it accidentally.

User No3



Male, Age 24 (Height 1,85)

User 3 continued to find the product ergonomic and easy to hold. He stated that the “*addition of the rubber material will make it perfect*”, which shows how important is the stable holding of the remote control.

He also stated that the signifiers are on point and “*it seems impossible for someone to be confused with that thing*”.



Concerning the on/off button he also stated that the placement of the button was on “*on point*”, but he proposed the button “*look slightly down*” so as to be pressed accidentally.



User No4



Male, Age 66 (Height 1.78)

In the previous statement the user said that this product is very unusual for a remote control, because he could not understand how it is going to be used. However this time with the signifiers added he stated that *“now it is clear to me”*.

He also stated that the previous remote control prototype was thicker and more difficult to hold it in relation to this one.



In addition to that he also stated that *“now it is easier to hold it”* and *“I am reaching all the button with no effort”*



He admired the fact that the on/off button is not placed on the touchpad because as he stated *“that would be very confusing”*.

User No5



Female, Age 27 (Height 1.70)

This user stated that the product is lightweight and it would be easy even for a kid to hold it. Moreover she stated that the remote control will definitely can be used as an ornament is its base because of the fact that is slim and it does not reminds a typical television controller.



She also stated that the addition of the rubber material is mandatory and like the fact that the on/off button is easy to be reached.



10.3.1 User Testing Phase 2 – Conclusions

The second round of user testing was also compulsory, for some final conclusions to be drawn. Users like the thinner shape and stated that now the product provides the users with the ability to hold the remote control more efficient and effectively. Moreover the addition of the signifiers seemed to impress them as they all expressed their excitement about it.

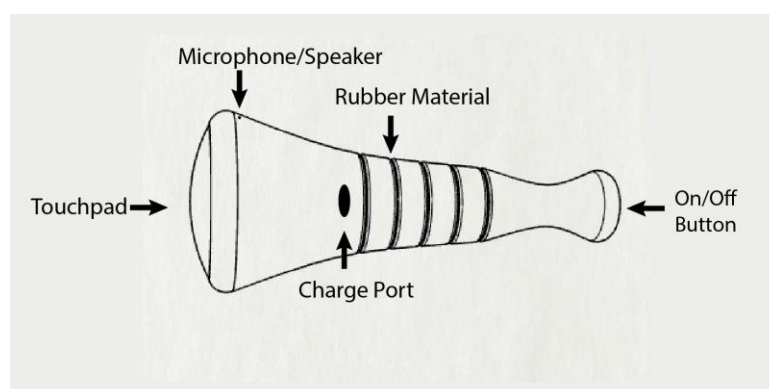


We can also understand that the on/off button's size is right but the accidentally pressing should be avoided. The solution to this concern is to make the button clickable and not very sensitive.

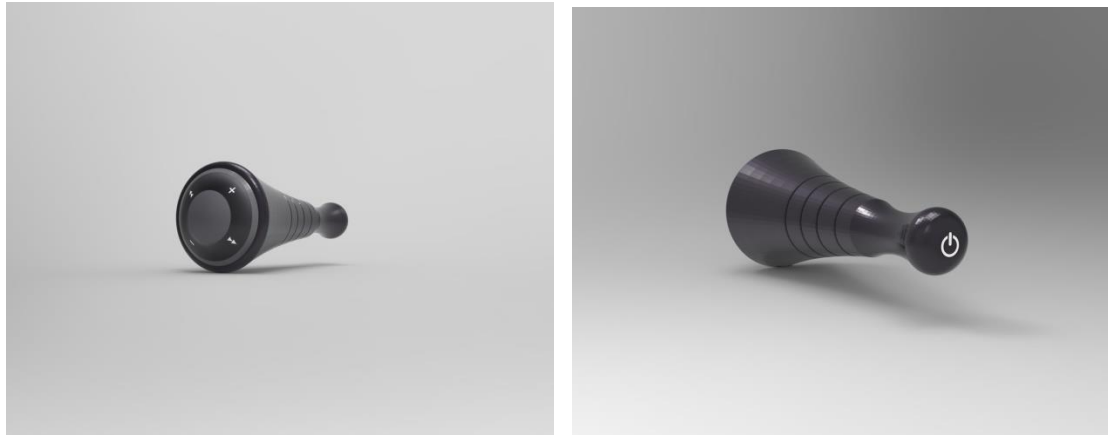
11. Final Product

11.1 General Description and how the product is organized

In the design brief it was specified that the product must provide indicators and signals for every function, with natural mappings and comprehensible affordances. The main purpose is to provide a product which offers intuitive experiences.

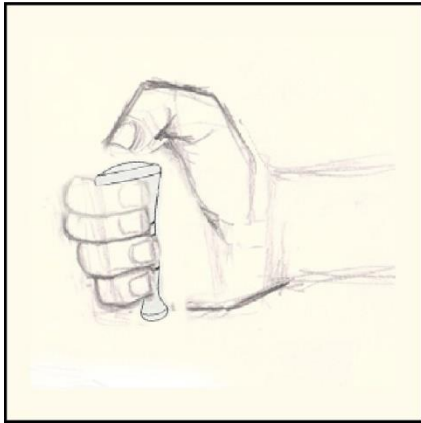


The fact that the remote control has only one button (the on/off) operates as a signifier and makes the user understand immediately how it works. In addition to that the arrows on the touchpad, (up/down and left/right) work as natural mappings minimizing the possibilities the user proceed to an undesirable actions.



Design Brief also indicated that not specialized language should be used. The signifiers have to be understandable for any user. The examination part showed that consumers cannot remember a lot of pre-fixed settings when they use a device. The remote control designed so as to not confuse the user as it includes three basic controls, the touchpad, the on/off button and the voice assistant as it mentioned before.

Moreover the design brief also dictated that the system should be organized based on functions importance or usage frequency in order to be understandable. The main reason why the product should be organized is the fact that the user does not have to be overwhelmed by a vast amount of information. In order to avoid this complexity the tools designed in a way that embraces the intuitive use. The users are familiar with the classic on/off button from other devices. The same fact applies to the touchpad. In today's technology almost everyone has interacted with a touchpad or touchscreen in their everyday life.



xlii

Another important aspect that design brief specified is the fact that the interface elements should be kept to minimum. The remote control does not include many buttons. In this part the voice control function plays a major role. Redundant factors that may confuse users such as rarely used buttons were removed. Settings and menus can be activated via the voice control, easier and faster. Reducing time and not confronting difficulties increases the feeling of simplicity.



To sum up, the top part of the remote control designed in a way to facilitate the thumb reaching into the desirable position. The rounded top helps the user navigate and choose the necessary function. Also the concept of forcing functions that mentioned before also taken into consideration in the design of this part. The shape of the remote control “forces” the user to hold the product efficient. As a user stated in the testing phase, it is important the product to follow the hands shape.



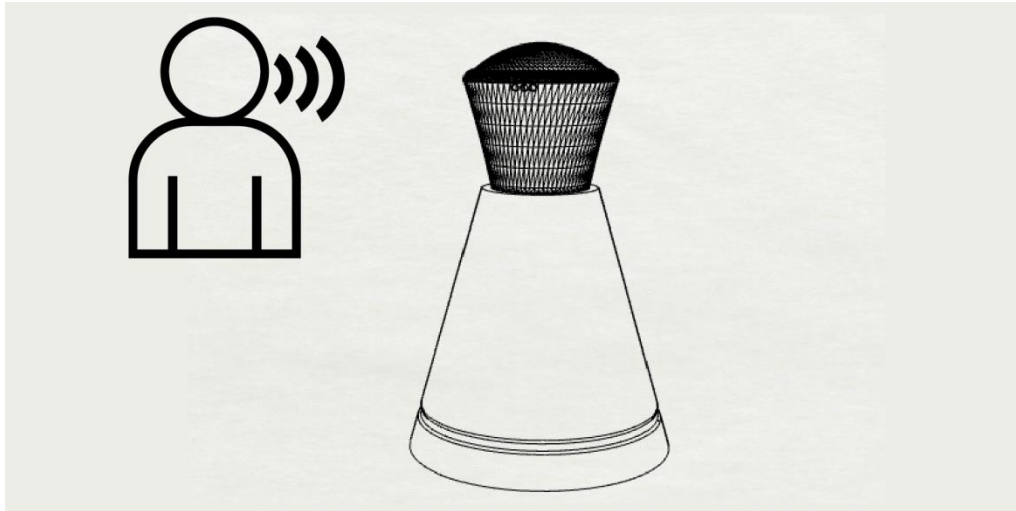
Concerning the charge port, as we talk about an electronic device the addition of a classic Type-C port (8.5 x 2.6 mm) is mandatory. In today's technology almost every smartphone and electronic gadgets uses the Type-C charger due to the fact that supports fast charging and it its reversible, so as to facilitate the plugging of the cable into the device.



11.2 Voice Control^{xliii}

As it analyzed before in the paper examination part, in order to facilitate the users, designers should provide them with the ability to customize the product based on their preferences. The fact that the product can be used either by holding it or via voice commands contribute to simplified use of the product.

Concerning the voice control the ability to interact with the product without holding it reducing the possibility of misunderstandings. The voice control system does not allow mistakes to happen as the remote is programmed to respond in specific voice commands.



11.3 Voice Control Technology explanation

It is noteworthy to analyze the voice control technology that is incorporated in many devices through the last years and can be used in this particular case.

Intelligent Personal Assistants (IPAs) developed upon artificial intelligence and information technologies. Their main reason of existence is to facilitate the products' use by answering questions via voice commands. Intelligent Personal Assistants (IPAs) have a major role in human-machine interaction providing the ability to communicate rapidly and effortless through Natural Language Processing (NLP). As these assistants answer questions via voice commands the users feel like they are having a real life conversation.

11.3.1 How the IPAs work?

The complexity of voice recognition technology has been evolved and can provide better and more accurate responses.

The software operates by listening to key words and phrases. The key word or phrase is going to be sent to the specialized server which supplies the voice assistant with the suitable information in order to provide the user with the answer and complete the task.

11.3.2 How the computer has the ability to understand language?

Computer always had the ability to understand human inputs by machine language instructions as well as high level programming languages. However those are structure methods with limited commands if we compare them to natural language.

11.3.3 What is the Natural Language Processing

NLP is a field of artificial intelligence, computer science and linguistics dedicated to make computers and machines to understand and interact with human.

Natural Language Processing combines everything a computer needs to process in order to generate natural language. This includes developing methods such as computational algorithms in order to answer in a short period of time efficiently.

Natural Language Processing requires lexical, syntactical and semantic analysis. Another requirement is the “discourse integration” which means that the system should take into consideration the context.

A lot of words have multiple meanings which can be used as nouns or verbs. A classical digital dictionary alone is not enough to resolve this ambiguity. So phase structure rules are created. For example a “sentence” is followed from a “noun phrase” and a “verb phrase”. Making rules like that the computer can understand how the sentence is structured.

For instance if the user asks a “what” question like: “What is the biggest restaurant”, the computer will understand that the noun is “the restaurant” and the dimension is the “biggest”. They can also process commands like “set the alarm” or “open the TV”.^{xliv}

11.3.4 Already existed products with the same technology

Ivee Sleek is a voice-activated alarm clock that has a variety of possible voice commands in order to help the users set an alarm, turning it on or off just by them voice. Ivee Sleek was one of the first devices supporting voice activated assistant, helping the user to set reminders and ask about common questions like the weather or a stock price. Moreover it could also connect with other devices such as thermostats or lights and control them via voice commands.



Ivee Sleek – Photo from products Kickstarter page



Ivee Sleek's Functions– Photo from products Kickstarter page

Another virtual assistant is Alexa which is connected with home devices and has many features like setting alarms, reminders, making lists and searching the web. Math calculations and calendar entries are also possible. Due to the fact that Alexa is almost always connected to the internet, provides the user with the ability to extend products capabilities by updating the skills, connecting devices and downloading third-party services.



xlv

Each assistant has its own feature, but the core functions are the same to all. Typical examples of more voice assistants are Apple's Siri, Google's Assistant and Microsoft's Cortana. However these are commonly installed in smartphones or personal computers. Voice assistants can be programmed using programming languages such as PYTHON and C++

11.4 How the feedback is provided to the user^{xlvi}

The functions of the product have to provide coherent feedback. Every time the user interacts with the touchpad the vibration mechanism is activated. Providing feedback simplifies the interaction process. The remote control besides the visible cues and indication offers advantageous information product's functions. The technology that is going to be used in order this to happen is the same that capacitive buttons in smartphones use



When those buttons in the above picture are being touched they provide feedback to the user by vibrating. This happens due to haptic technology.

Haptic technology is the science of applying touch sensation and control in order to interact with electronic devices. To begin with, haptic technology enables the user to interact with a virtual environment so that when virtual objects are touched, they seem to be real and tangible. This also applies in the case of the remote control's touchpad. To be more specific, the feedback provided by the touchpad would be a motion, such as vibration.

A Haptic system includes two different parts, the human part and the mechanic one. Both the systems are consisted by necessary sensors, processors and actuators. In the figure 1, the mechanic part seems to simulate the human part of the system. In other words, sensors which are used in the mechanic part play the role of nerve receptors which perform sensing in the human part. Furthermore, brain performs actuation of the motion performed by the hand which is represented by encoders, compute and motors respectively in the mechanic system.

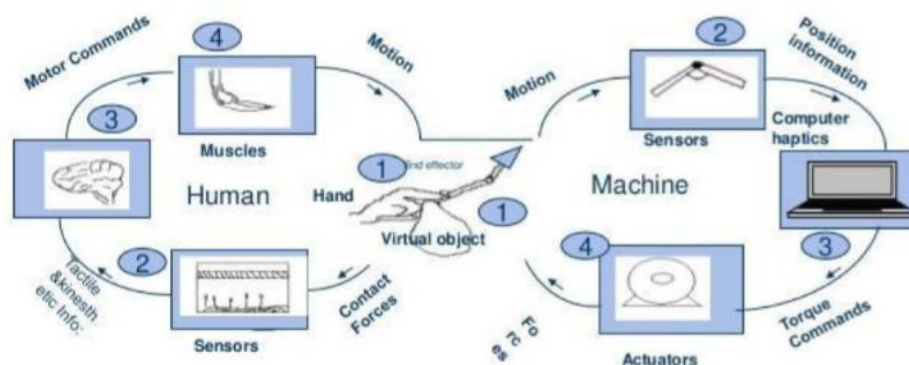


figure 1

Typically a haptic system consist of

- Sensors
- Actuator control circuitry
- Actuators which vibrates or exerts force
- Real time algorithms and a haptic effect library
- Application programmable interface (API)
- Haptic effect authoring tool

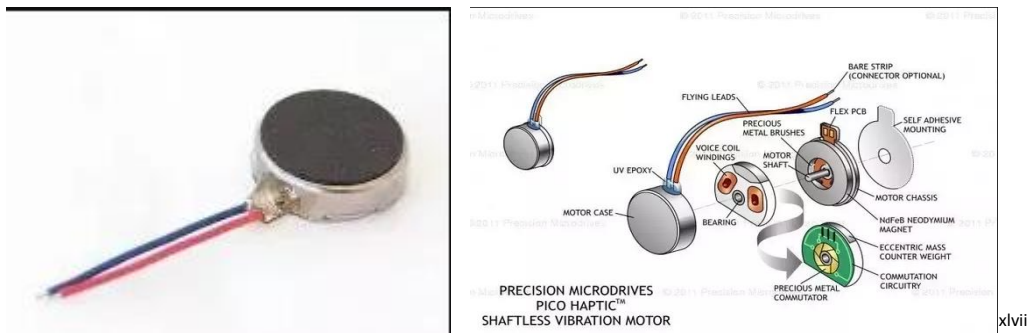
Among the many components inside the device is a small motor. The motor is built in such a way that it is partially off-balanced.

When the user's fingers moves, the sensors translate those motions into actions on a screen. Thus motors transmit feedback through the linkages to the fingers of the user.

In other words, a mass of improper weight distribution is attached to the motor's shaft/axis. So when the motor rotates, the irregular weight causes the device part to vibrate.

A cell phone is such an example of an electronic device that contains a vibration motor. Another example can be a rumble pack of a game controller that shakes, imitating the actions of a game.

The motors that are used in mobile phones and other electronic devices really are very tiny. some of them aren't much bigger than 4 mm across and maybe 10 mm long, with a shaft well under 1 mm in diameter.



It is placed like this:



xlvi

Whenever the motor rotates, the off center weight distribution causes some vibrations and since it's attached to a device, it vibrates

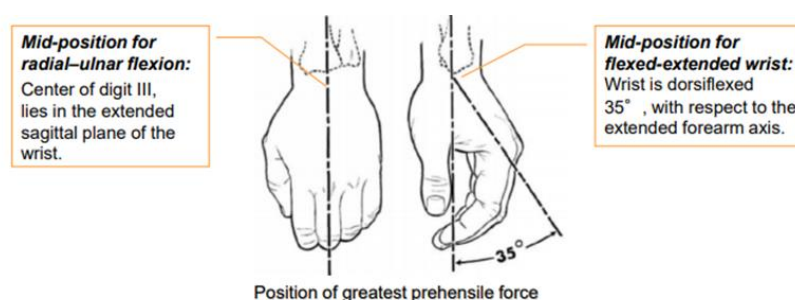
11.5 Software

The operating system that is suggested is the Linux. Operating systems based on Linux are used in embedded systems like electronic devices, network equipment and smartphones or tablets. Routers, wireless access points and navigation equipment devices are also based on this software. Linux kernel based systems can be applied in many fields and different equipment due to the fact that the software is open source, that means that anyone can modify it according to their needs, and it is completely free. A typical example of voice assistant device that using Linux is the Ivey Sleek alarm clock that mentioned before.^{xlix}

11.6 Ergonomics

In the ergonomics part in was mentioned that the target audience is basically every person who watches television, from kids to adults and elders, so the remote control designed in order to provide intuitive use. The remote designed based into the anthropometrics chart with the intention to fit even the smallest hand. Moreover the remote control is easy to be used from people with dexterities. Identical buttons that may confuse the users were avoided. Touchpad and on/off buttons are completely different in size and shape. In addition to that, users and especially people with visual dexterities do not have to look at the remote control and search which button serves their purpose. The design of the part three provides the user with the ability to understand where the fingers are placed and as a result the use in the night is being easier.

The product facilitates the user holding it and also finding the controls. Button size and shape leads the user to the desirable action even in the dark Based on the anthropometrics chart the remote control shape is following hand's "rest position".

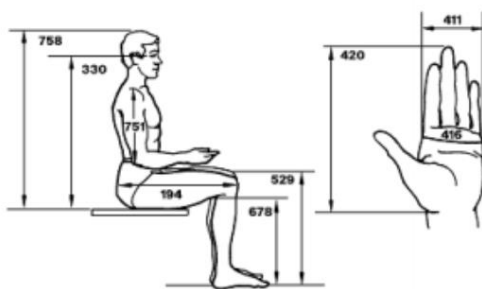


The reason why the bottom part of the product is designed in this way is to accommodate the better holding. As we talk about a hand operated device is important to take into consideration where the fingers are going to be placed.

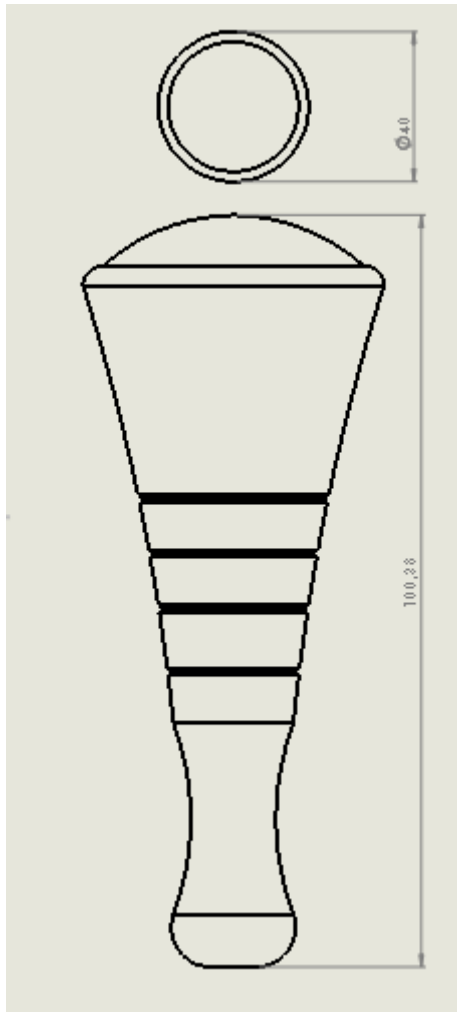


Concerning the dimensions it mentioned before in the prototype staging that the design should be applied even to the smallest hand. In the anthropometrics board the smallest hand is represented by the 5% hand breadth dimension (411). That means 8.2cm. However the product should be bigger than hand breadth, therefore the product designed a little bigger (10.38cm instead of 10.00cm) than the suggested prototype dimension.

Anthropometric data seated U.S male (2000)
source NASA



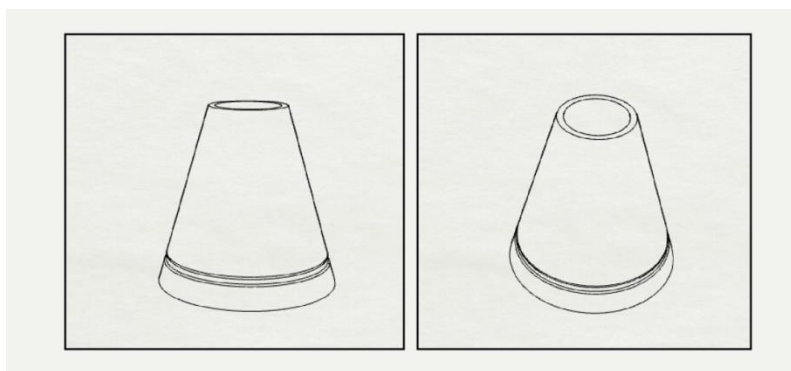
Dimension No.	Dimension	Percentiles		
		5th	50th	95th
758	Sitting height	88.9 (35.0)	94.2 (37.1)	99.5 (39.2)
330	Eye height, sitting	76.8 (30.3)	81.9 (32.2)	86.9 (34.2)
529	Knee height, sitting	52.6 (20.7)	56.7 (22.3)	60.9 (24.0)
678	Popliteal height	40.6 (16.0)	44.4 (17.5)	48.1 (19.0)
751	Shoulder-elbow length	33.7 (13.3)	36.6 (14.4)	39.4 (15.5)
194	Buttock-knee length	56.8 (22.4)	61.3 (24.1)	65.8 (25.9)
420	Hand length	17.9 (7.0)	19.3 (7.6)	20.6 (8.1)
411	Hand breadth	8.2 (3.2)	8.9 (3.5)	9.6 (3.8)
416	Hand circumference	20.3 (8.0)	21.8 (8.6)	23.4 (9.2)



Technical drawing are presented in the appendix

11.7 Base

The base of the product designed in order to make easier for the users to place the remote control when they are not using it via the touchpad. Base does not have any electronic properties. It stated in the design brief that the remote control has to differentiate form other controllers and to be recognized as an independent product. As a result the design of a base-holder is crucial for this purpose.





Technical drawings of the remote control and base are presented in the appendix.

11.8 Materials

Most of the electronic devices are made out of plastic. Plastics can be treated in numerous ways depending on their properties. Because of their low cost and lightweight they are the preferred material for many industries. Packaging, automobile production, construction and manufacturing are some of them. In addition to that electronics and household appliances are made out of plastics. However not all plastics are ecological friendly. That's why the last years manufacturers prefer bioplastics.

Bioplastics are comprised in a substantial part or even entirely from sustainable sources. Bioplastics are biodegradable, that why the plastics based on petrol does not

belong in this category. Bioplastics can be produced from renewable natural materials in raw form. Plant oils and natural polymers can be acquired and through processing converted into ecological friendly plastics.

The material suggested for the remote control and the base is PLA¹

Polylactic Acid (PLA) is derived from renewable sources, mostly biomass. It has almost the same characteristics with the polypropylene (PP). However the most significant characteristic of PLA, which is the main reason of differentiation with other materials, is that it naturally degrades. No further process is required.

The fact that it can be made out of manufacturing equipment that already used is one of the reasons that manufacturers prefer it, not to mention the relatively low cost. In addition to that, the properties of transparent PLA's allow to the manufacturers to process it without extra modification. That happens because it performs as a typical plastic which can be found in mass production.

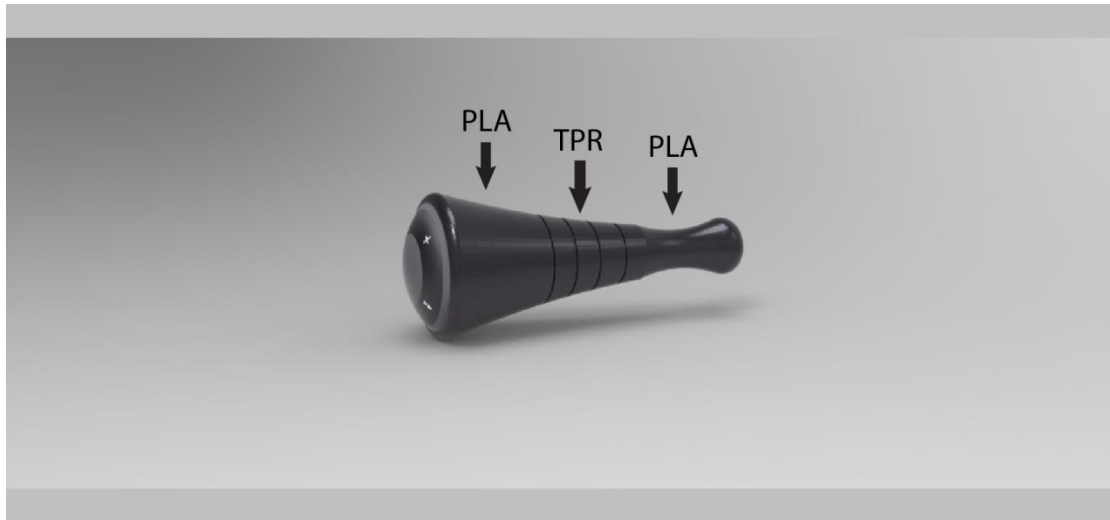
Moreover PLA is one of the most common materials to be used in 3D printing. It is available in filament form and can be found in many different colors providing the manufacturer with many options

PLA can be used for short-life product packaging such as food and beverages but it can also apply on most durable applies. Typical examples are casing of mobile phones, desktop accessories or even dashboards in automotive industry.



DASHBOARD IN AUTOMOTIVE INDUSTRYII

The material that is suggested for the rubber part of the remote control is TPR. TPR is a material with many uses, mainly in automotive industry. In addition to that its non-slippery properties made it one of the most used common used materials in products such as cables, footwear and toys. Typical applications of TPR also contain packaging, gaskets tubes and hoses. TPR is easy to combine with other materials such as stainless steel and nylon, not to mention the fact that is water resistible.



11.9 Exploded Views





12. Remote Control features – Explanation

Scenario no. 1

The user wants to watch television and reaches for the handset.

Feature A. – Silent Mode (Use via the touchpad)

A.1 In order to turn on/off the television, the user presses the on/off button in the controller.



A.2 The user wants to change the channel via the touchpad.



A.2.1 The user want to change to the previous channel: They slide with their thumb (from right to left) in the (<<) signal.



A.2.2 The user wants to change to the next channel: They slide with their thumb (from left to right) in the (>>) signal (the same way with the previous action)

A.3 The user wants to adjust the volume via the touchpad.

A.3.1 The user wants to increase the volume: They slide with their thumb from the bottom (-) to the top (+).



A.3.2 The user wants to decrease the volume: They slide with their thumb from the top (+) to the bottom (-) (the same way as the previous function)

Scenario no. 2

Feature B. – Voice Control

B. The user wants to watch television without using the touchpad. The remote control is either placed on its base or everywhere in the living room.

B. In order to turn on/off the television the user uses the command “turn on” or turn “off”. The remote control via the microphone is going to open the television.

B.1 The user wants to change channel

B.1.2 The user wants to change channel: They have to use the change channel commands which are: “Go to (channel name e.g. CNN)” or “channel 1 (2 or 3 etc.)”

B.2 The user want to switch to the satellite/antenna or pay television: They use the command “go to (e.g. satellite). And then they use the command mentioned in B.1.2 section.

With the same command the user can open television apps, for example: “Go to Netflix”, or switch to HDMI “Go to HDMI”

B.3 The user wants to adjust the volume via voice control

B.3.1 The user wants to increase the volume. The commands they can use are: “Set the volume to 5” or “increase the volume” which is going to increase the volume by one point.

B.3.2 The user wants to increase the volume. The commands are: “Set the volume to 5” or “decrease the volume” which is going to decrease the volume by one point.

B.3.3 The user can mute the television by using the command “Mute” and unmuted by using “Unmute”

B.4 The user wants to navigate to the menus. They have to use the command “Menu” and then the name of the menu part. For instance “Volume Settings”. They can also navigate using the touchpad (left/right, up/down)

B.5 The user want to go back or undo: The command they have to use is “Go back”.

The point is to eliminate functions such as navigation to happen using the buttons. These actions are very difficult and frustrating and difficult as the users stated in the controller reviews. That why the most features are going to happen via the voice control and the only the main (as the users stated) actions are going to happen via the touchpad.

Concerning the commands, the command: “go to” is included in the most features. This happens because as it was analyzed in the research parts users do not remember more than two or three pre-fixed settings.

13. Final Conclusions

The main idea of this study was to improve on a remote control making it comprehensible and intuitive for human use. In order the product to be functional and understandable, complexity should be avoided and ergonomics had to be taken into consideration. Inexperienced user and people with dexterities can use the product without being confused due to the fact that a lot of buttons are identical and placed near to each other. In this remote control the buttons/controls number is minimized and voice control added so as to simplify the operation. No product is going to be successful if the design does not taken into account the actual customer needs, avoid any design stereotype and start from the scratch.

14 Appendix

14.1 Voice commands list

Voice Commands List

1. Change volume: “Set the volume to 5” or “turn up/down the volume”
2. Mute: “mute/unmute” the TV
3. Change channel: “go to (channel name) or channel 1,2 etc.”
4. Switch to satellite/antenna/pay tv: “go to (satellite for instance)”
5. Change inputs: “switch to HDM1”
6. Go to menu: “menu”. The navigation in the menu can either happen via the touchpad (left/right, up/down) or by calling the name of the menu part: “Volume Settings” for example. Other examples such as opening the TV Guide work in the same way. “Open TV Guide” or “Date and Time Settings” etc.
7. Open apps in smart TV’s: “go to Netflix” for instance.
8. Turn on/off the TV: Except of the physical button voice commands can be used: “turn of/off”
9. For undo: “go back”
10. If the television supports profile creation with user preferences (for screen or volume pre-fixed settings) the user can use this command: “Use profile 1” etc.

14.2 Other materials that can be used for the construction of the product

Polyhydroxy alkanoates^{lii}

Bioplastics can be derived from starch and other substances that supply carbonates by fermentation and the action of micro-organisms. Those are called polyhydroxy alkanoates (PHA). The family of those bioplastics contain and other materials such as PHB, PHV and PHBV. PHAs are derived from renewable sources and they can biodegrade. They are also biocompatible which means that they are not injurious for the environment and the living tissue.

Applications^{liii}: it is considered for applications like packaging, molded goods, paper coatings, non-woven fabrics, adhesives, films and performance additives.

- Single use packaging for foods, beverages, consumer products, etc
- Medical applications like sutures, bone marrow scaffolds, bone plates, etc
- Agricultural foils and films

Polyethylene Furanoate (PEF)^{liv}

PEF is an alternative to petroleum-based PET and it is completely bio-based. It is produced from sustainable materials which come mostly from plants and it recyclable. PEF is an ideal material for the packaging industry with application in alcoholic and non-alcoholic beverages.

Key Applications^{lv}

PEF's properties and its low cost provide manufacturers with the opportunity to use it in the packaging industry instead of the classic materials such as PET. When it is use in a large amount of production it can compete in price and performance to traditional materials.



PEF Bottles, Films and Fibers which are fully bio-based and recyclable are used instead of the PET. PEF offers safe, recyclable and rigid packages as the pictures show above with excessive performance.

Polybutylene succinate (PBS)^{lvi}

PBS is a biodegradable bio-based polysuccinate. Its properties are similar to polypropylene. PBS decomposes naturally to water and oxygen and it can be an alternative to conventional plastics. It can be used in the packaging industry as it can be processed into bags, boxes either for food or cosmetics. Moreover it can be found in other application like disposable products such as egg cases or tableware.

Examples of PBS applications

- Packaging and Disposables (food packaging, coffee capsules, food service ware as we mentioned before)
- Agriculture (Mulch film, plant pots)
- Fibers and Nonwovens (Hygiene products like diapers, Fishing nets and lines)
- Industrial/Automotive (Wood-plastic composites, composites with natural fibres)

Unsaturated polyester resins^{lvii}

Unsaturated polyester resins (UP) are materials that being used in boat building or for repairing damage bodywork in automotive industry. Polyester resins are produced from renewable resources.

These types of resins are useful in making trays, shower stalls, boats, swimming pool, water tanks etc. Acrylic modified unsaturated polyester resin having good cracking resistance, flexibility

PA 11^{lviii}

Polyamides are commonly used for industrial and mechanical applications. They can also be used for the production of technical fabrics and textiles for clothing. The bio-based PA11 is dominating the market for the last years. It is biodegradable and it

comes from castor oil plants. Because of its properties and especially from its resistance is usually being used for the construction of components such as pipes and fuel injector's parts. PA 11 is a high performance polymer which comes from a completely renewable origin, the castor oil. High impact strength, flexibility and good chemical resistance provide the ability to mechanics to process it easily and to use it for multiple purposes. That means that it is capable to be used for mechanical applications in automotive industry in functions such as fuel lines and in construction supporting oil and gas pipes. Electronic devices components are also easy to be constructed with PA11.



Fuel injector nipple made from 100 % biobased PA 11lix

Liquid wood^{lx}

Lignin-Based materials are cost-effective, recyclable and bio degradable alternatives for petroleum-based thermoplastics. The most famous bioplastic material based on lignin is the “liquid wood”. Liquid wood is a biodegradable biopolymer which performs as a plastic. However its color and smell is similar to wood. It is 100% biodegradable and its physical properties are similar to those of polymers.



Loudspeakers made from a lignin-based bioplastic^{lxix}



Watch made of liquid wood

Celluloid is considered as the first plastic discovered. It is made from cellulose nitrate and camphor and has a wide field of applications like decorative manufactured good, spectacle frames, picture graphic films and other similar products. Celluloid is still being used for the manufacturing of musical instruments such as guitars. It is easy to be processed, especially by molding and it is very resistant.

Cellulose derivatives^{lxxii}

1. Cellulose Acetate(CA with acetic acid)

Spectacle Frames

Early frames for spectacles were cut from sheets of cellulose acetate. While use of cellulose acetate has largely been superseded by injection molding with more modern thermoplastics, some up-market spectacles are still made in this way. This is most often the case when color blends/effect cannot be produced by injection molding. A popular example is the imitation tortoise shell effect.

2. **Cellulose Propionate (CP)** with propionic acid, is a thermoplastic polymer and derivative of cellulose when reacted with propanoic acid. CP is more transparent, glossier and stiffer than CA and CB. Although, the weathering resistance of CP is lower than CA and CB. Additionally, CP is an expensive material in comparison to other cellulose derivatives.

Applications

- Spectacle frames - injected around the hinges of the frame. Used for its low weight and superior optical properties to other commonly used polymers.
- Goggles - dual-layers in visers with other polymers. Used due to its excellent optical properties.
- Tool handles - as it is lightweight it can help to reduce the weight of the tool.
- Covers for television screens - gives the screen suitable protection from impact.
- Cutlery handles - high chemical resistance if contacted by acidic food products.

Casein is the protein component in the milk of mammals that is not found in the whey. Casein was one of the first raw materials for the plastic galalith. This plastic was used for the button manufacturing, decorative items and also for insulation materials in electrical installations.

PBAT^{lxiii}

Poly(butylene adipate-co-terephthalate) (PBAT) is a copolyester which is absolutely biodegradable.

When PBAT gets in contact with environment, it degrades within a few weeks through the intervention of natural enzymes.

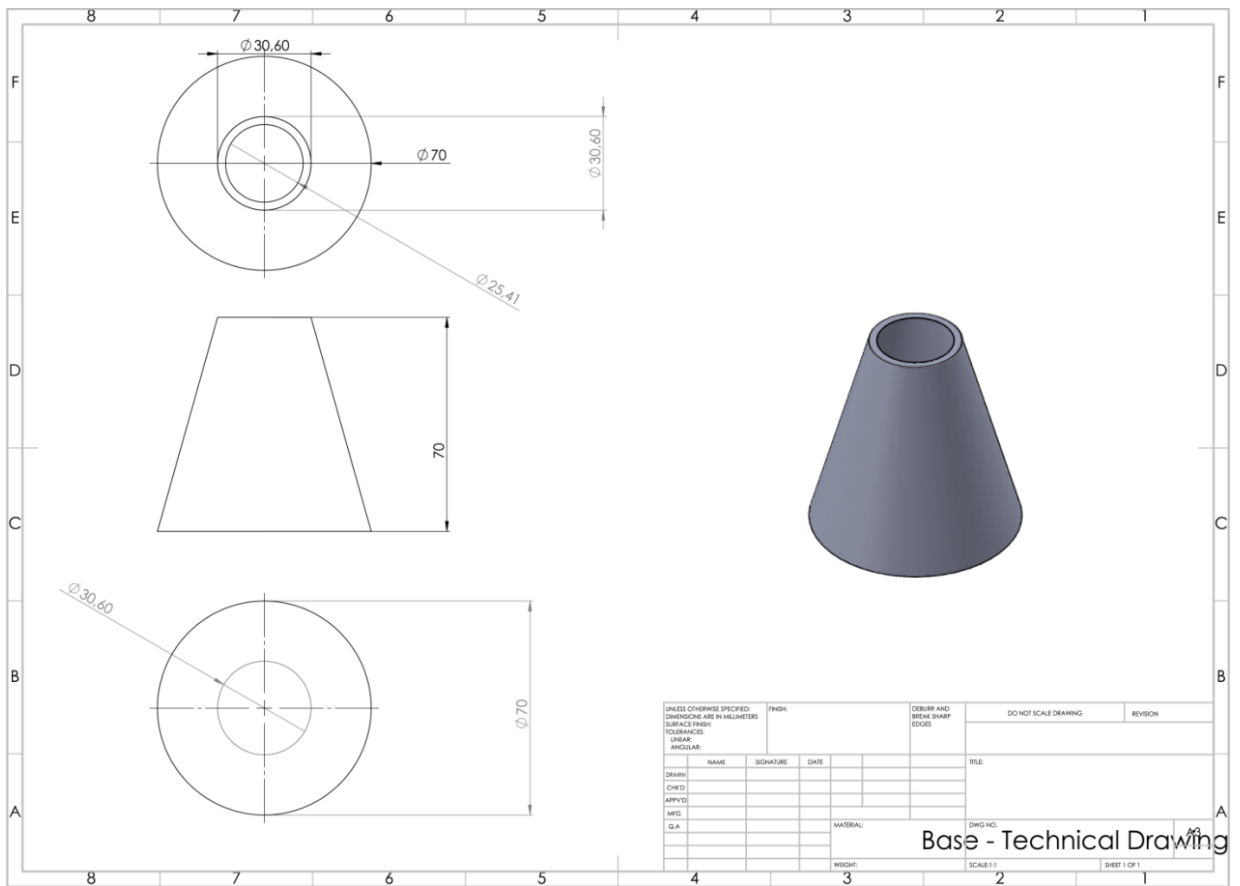
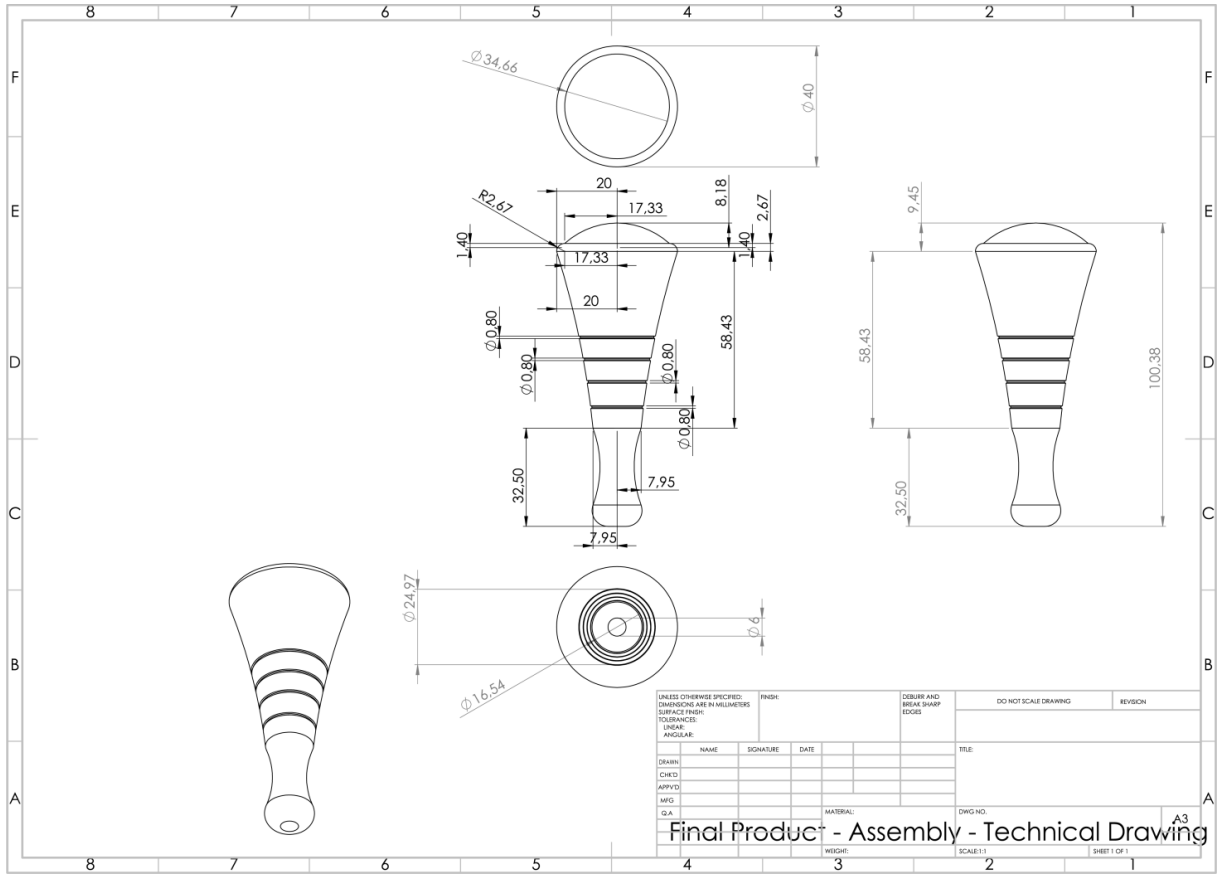
This polymer can be extruded to fabricate films and coatings (Jiang and others 2006). PBAT is being used in application such as fabrication of agricultural films, film lamination for rigid food packaging and lawn waste bags (Herrera and other 2002)

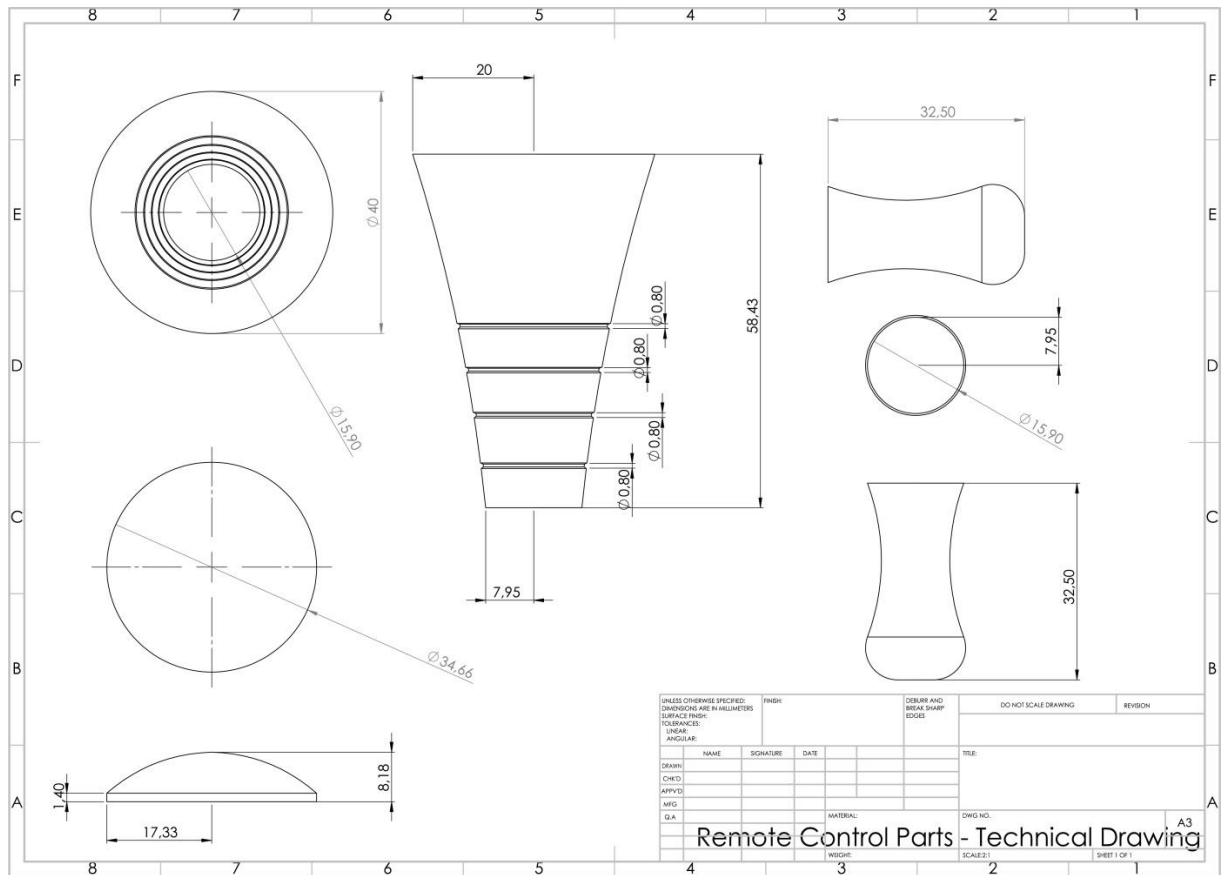


Products produced from PBAT

14.3 Technical Drawings

Technical drawing of the remote control and the base are presented below:





15. Sources

- ⁱ John Maeda – *The Laws of Simplicity*, The MIT Press- page 2
- ⁱⁱ Donald Norman (1988) *The design of everyday things*, Basic Books
- ⁱⁱⁱ Jane Lessiter, Jonathan Freeman, Andrea Miotto, and Eva Ferrari, 2008, *A Comparative Study of Remote Controls for Digital TV Receivers* [Online] Available at:
<https://pdfs.semanticscholar.org/f5cb/4d97eda1b0e7646c444bf15a1548acca024e.pdf>
 Salzburg, Austria — July 03 - 04, 2008
- ^{iv} Donald Norman (1988) *The design of everyday things*, Basic Books – Page 2
- ^v Donald Norman (1988) *The design of everyday things*, Basic Books – Page 2
- ^{vi} Donald Norman (1988) *The design of everyday things*, Basic Books – Page 3
- ^{vii} Donald Norman (1988) *The design of everyday things*, Basic Books – Page 17
- ^{viii} Donald Norman (1988) *The design of everyday things*, Basic Books – Page 23
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