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1. Context

Description

The product is an interactive virtual mirror which, when put into the context of the fashion industry, will pave the way for an innovative technological experience whilst retaining the fundamental importance of human interaction.

MirrorMirror, when placed in a traditional changing room, utilizes state of the art software to recreate a live feed image of the customer on a full-length LCD screen, mimicking a traditional mirror. However, the product will not only show a reflection, it will also register the shape of the customer in order to start a tailor made fitting process. This will allow the customer to select various items, designs, sizes and finally try and buy a product, all without leaving the comfort of the dressing room.

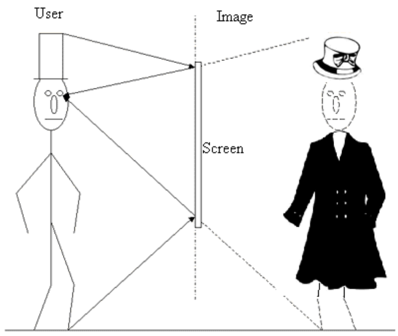

Figure 1
The left hand side shows the real person, the right side shows the enhanced image as viewed by the user

The fashion industry has seen a recent boom in the value clothing sector with the introduction of big ‘no frills’ chains such as Primark and ASDA offering high street fashion at low prices, which means they are able to turn out new designs and concepts at an alarmingly fast rate. Mintel estimates that the value clothing sector has outperformed the rest of the clothing market and that value specialists now account for 15% of all clothing specialists’ sales.[i] As a result, many of the middle and top end high street stores are suffering due to a slump in consumer confidence and by falling growth in clothing sales. The influx of value fashion has forced the specialists to re-think their value proposition, with the mid-market in particular feeling the squeeze. There has been a major drive for efficiencies and a rising interest in green issues, but according to Mintel, market experts see little room for further price cuts[ii]. We believe that the MirrorMirror concept provides a groundbreaking solution in the future of high street shopping, using new technology to interact with customers and give them a truly unique experience.

As the nature of shopping begins to change towards an experience-based shopping trip rather than simply a marketplace where goods can be exchanged for money, more and more retailers are recognising the value of incorporating experience areas into their stores. For example, in Selfridges, there are now “experience areas” incorporated into its stores with events such as fashion shows. Retailers are becoming more interactive and more hands on and many more interactive experiences in stores are now taking shape; mobile phones are switched on, televisions actually work, Hi-Fis can be touched and the volume altered. This is a strength in today's store design that will become ever more important as stores need to embrace the experience of retailing for their customers. MirrorMirror is just another step in this evolving process.

The tendency towards a more interactive shopping experience coupled with the reduced price of technology results in MirrorMirror becoming an ever more realistic technological solution. It is a realistic option to put in flat screen TVs, large video walls or technology that can talk or has visual images. As a result of MirrorMirror, the store has a novel method for delivering sales messages. According to Mintel forecasts, in-store technology will continue to grow in importance and will be used in ever more sophisticated ways. It will give retailers flexibility about how to service their customers' needs, as well as allowing customers more options in how they shop[iii]. Fundamentally, in-store technology can be used to enhance the whole design of the store and is likely to continue to be used further in this creative way.

Not only does MirrorMirror technologically enhance the store, the product addresses some key problems found in the shopping process for both the consumer and the store, as seen below.

Consumer

Tailored Clothes

One of the biggest problems is the fitting process of clothes. It is though that many people buy clothes that are the wrong size due to the fact that they do not actually know their body type and therefore optimum clothes style. Over 80% of women wear the wrong bra size[iv]. Not only does the MirrorMirror scale the virtual item of clothing to fit you, it will also determine what size of that item would be most preferable for you particularly.

Larger variety of items

A major problem area when it comes to shopping is the amount of time it takes. Women make over 250 trips a year with the sole purpose of shopping[v] and although many do go in to 'window shop', the majority of people in a fast paced lifestyle feel that they do not have enough time to browse the collection to their full capacity. The mirror will allow the user to glance through the whole range of items, including variants of style and colour at the touch of a button.

Individual shopping

With the amount of choice in the industry, shoppers now want retailers to go beyond their normal service and provide recommendations as to what to purchse[vi]. Much like the 'Amazon.com' technology that saves your preferences and suggest other items that might interest you, the mirror will keep a memory of styles viewed and items purchased or tried on to make the experience more personalised. Analogous to a personal shopper, the mirror will not only tell what items would suit you, but could also potentially match up an item with an item bought on a previous visit.

Online sales boost

Online shopping continues to grow in the UK and cannibalise store sales. It is popular with customers and continues to take market share, taking browsers away from the stores. Retailers must enhance the physical shopping experience to offset this, though online sales are expected to peak at 10% of all clothing retail sales. MirrorMirror provides the perfect solution by employing the technology available on an online catalogue and tailoring it to the customer.

However, internet shopping is not being used to its full potential. It only makes up a very small percentage of total sales, an issue that MirrorMirror hopes to address. In a recent survey, it was found that consumer hesitancy is caused for many reasons. In January 2000, a study by E-BuyersGuide.com, a multi-channel market research firm, sought to uncover the reasons why shoppers are hesitant to make apparel purchases over the web[vii]. Of particular note is the consumer's overwhelming concern with fit and correct sizing (27.95%), concerns with having to return garments (18.17%) and the inability to fully evaluate a garment (quality, details, etc.) (19.76%). All these issues can be dealt with by the product. The fact that the mirror tells you your size means that any online purchases are automatically tailor made, leaving customer satisfaction high and increasing sales and customer loyalty. The other issues assume that the customer will not be visiting the actual store itself. The online service that is provided is aimed to be an aid to the in-store experience, meaning that if an item is seen online, the preference can be saved and then looked at in detail in-store if needed.

Store

Increase in sales

Today's sophisticated consumer is demanding in-store improvements. According to Mintel market research, one in three shoppers want better stock availability, quicker service and improvements to changing rooms. These three issues would be addressed by MirrorMirror. The interface allows the customer to request an item of clothing which would then be waiting for them at the till, thus improving service. What better improvement could you ask from a changing room than the novel interactive mirror! Moreover, the statistical analysis carried out by the software behind the interface would allow the shops to be able to predict long term trends accurately and stock clothes that their own customers require, instead of having to rely on more general market research. In smaller branches the virtual changing room could replace some racks of clothing and this could create more storage space for a more Argos style shopping experience where you decide from your virtual catalogue of clothes on your screen. However, the biggest reason the store would buy the mirror is it has the potential to increase sales drastically. The interactive experience will allow consumers to view a larger number of products in a shorter time, increasing the probability of finding a suitable garment. The fitting function of the product would allow clothes to look better more of the time and hence, psychologically, make shoppers feel more comfortable and likely to buy. The background of the changing room could be adjusted to see what a dress might look like in party lighting and thus allowing the customer to make a more informed decision.

Marketing

The mirror would be able to store the entire collection and so within a visit, could suggest other items to buy and promote certain styles more than others. The heuristic method of advertising in this case could be extremely persuasive, as the consumer would feel it to be less invasive than the other methods.

Market research

Rather than hiring out specific companies to perform market research into what consumers want, the memory function of the mirror will allow shops to have a direct insight into the items that are popular and those that aren't. The interactive nature of the product allows simple questions to be added to the experience such as 'Were you happy with your experience today?' or coupled with images, 'What style do you like better?' This will increase industry knowledge about what the consumer really wants.

Customer loyalty

According to the report "Retail Store Design 2007", today's consumers are fickle and the average consumer has a lower boredom threshold for shopping than ever before. Reduced loyalty makes consumers move from store to store, hunting for special offers and this is encouraged by the internet. It is a challenge for store design to improve the loyalty of shoppers, tying in multi-channel retail experiences to good design in order to encourage shoppers to return automatically to their store. A novel gadget such as MirrorMirror may just be the perfect solution to these lower levels of loyalty. Furthermore, by having a customer account at the store on which preferences are saved, the consumer will be more likely to return to the store as they have already invested time into the mirror. The memory function here plays a big role as it will act as a pulling factor when consumers are looking for a personal and efficient shopping experience. This loyalty will extend to the internet and also help market the product and the store by word of mouth, encouraging others to use it.

Exclusivity in market

This innovative idea has the advantage of being very rare in the industry. Most stores and nearly all consumers will have never had an experience like this and so the store that gains the right to the product will be a huge attraction when the product is first released. Much like the shoe fitting machine at Clark's shoe store became iconic to that particular store; the mirror would serve the same purpose for whichever store buys it.

As mentioned earlier, stores such as ASDA and Primark are constantly increasing the quality and appeal of their clothing lines. This calls for current middle end stores to become more resourceful and innovative in their approach to attracting customers. MirrorMirror is the perfect addition to these stores that are trying to create a particular ambiance and novelty that is otherwise unavailable in big chains. These middle end stores will be able to provide shoppers with the opportunity to find a wider variety of styles that they like and try on more clothes, thus increasing sales. Shoppers will be delightfully pleased with the unique experience of the mirror and return to the store the next time they are in search of a most flattering outfit. High-end stores, on the other hand, due to their consistent customer base, do not necessarily need to increase their sales. However, they will be able to provide their customers with something of an expected luxury. In fact, upon use, customers of high-end clothing stores might even be inclined to purchase a MirrorMirror of their own to organise and improve the accessibility of their personal wardrobe, contributing to the evolution of the MirrorMirror into an eventual common household convenience.

Scope for profitability

Releasing technology into the fashion industry is highly likely to create profit. The clothing sector is the second largest in UK retail. The fashion industry has seen robust growth through 2007 despite deflationary pressures and clothing will outperform both non-food retailers and the overall retail sector with a growth rate of 18.4%. This is reflected in the sales growth shown by the Gruppo Intidex, which is the retail group that runs Zara, Berskha and Massimo Dutti amongst other mid-end high street stores. Taking this group as a case study throughout this report allows more accurate estimations to be made. Gruppo Intidex has seen an estimated 75% growth in sales in the UK over the last 2 years[ii].

Pricing

It is important to estimate what the high street stores are prepared to pay for the mirror. When considering this two approaches can be employed; Cost-Based Pricing and Price-Based Costing. Cost-based pricing considers the input costs including components research and development etc. In the costing section below we go into the details of the cost breakdown of MirrorMirror and our estimated cost for building the first prototype comes to £1,45 million. Further to this the cost of producing each interactive mirror unit would be £13,900.
If the price-based costing approach is to be employed it is useful to know that the average spending on store refits ranges from £50 per sq ft to over £600 or £700 per sq ft[iii]. Considering that the average Zara store in the UK is just above 10,000 square feet[ii], but the changing room would be about 5% of this space, we can estimate that they would be willing to spend about £150,000 on the changing rooms.
Another consideration is the amount spent by stores on advertising. Although Gruppo Intidex do not spend a lot on advertising, this policy is not representative of fashion retail as a whole and Mintel[viii] estimates that advertising spending by the top ten retailers has doubled in the past four years to £114 million. This is evidence that the high street brands are willing to spend on advertising, suggesting that they would jump at the opportunity to be able to advertise their clothing line so effectively to the consumer from the comfort of the changing room. For these reasons we do not feel that pricing the product MirrorMirror at £50,000 would be unreasonable.

2. Technical Solution and Underlying Physics

The central functionality of the system is to give the impression of a genuine reflection, which is in fact a camera display which has been enhanced by software.
This section outlines methods to achieve this goal; there are multiple approaches possible to achieve the illusion, which would need to be investigated and tested in the development stage of the product.

Main features and equipment

The product would consist firstly of a large screen and a camera placed facing the user to capture a constant video feed. The possibility which provides the most convincing illusion of a mirror would be to place a half-silvered mirror angled at 45˚ to the user in front of the screen to allow a camera to be pointed, indirectly, straight at the eyes of the user by placing it at the side of the screen. Figure 2 illustrates the optical path which allows this illusion to function.

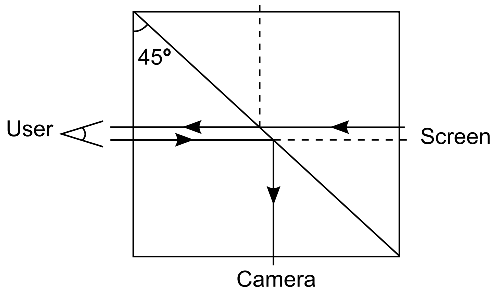

Figure 2
The optical path which allows a camera to be placed indirectly at the eyes of the user without being seen

Face recognition software would be required to track the eyes of the user, which would then allow automatic and rapid adjustment of the position of the camera in vertical and horizontal directions so that it may constantly be directed at the eyes of the user. In this way the user may always see an output on the screen which is completely convincing in its replication of a mirror. Any other more simple method would inevitably result in the camera not being directed at the user's eyes at all times, and an angular skew would be visible in the video output. Whilst this may only be small, it is possible that the user may sense that the output is not correct, or natural.

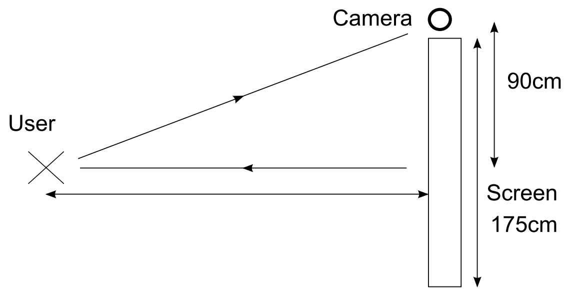

Figure 3
Simpler method consisting of a camera at the side of the screen

Investigation of this effect would be required in development, and testing of an alternative method, which requires simply that a camera is placed at the side of (or above) the screen, would be an obvious move. This setup is illustrated in Figure 3. One camera functioning in this way would provide a reasonable approximation to the output of a mirror, provided that the user stands sufficiently far away that the angular skew of the camera being at the side would inevitably provide. Though the angled mirror variant would require more space and equipment, it would always provide the most convincing illusion.
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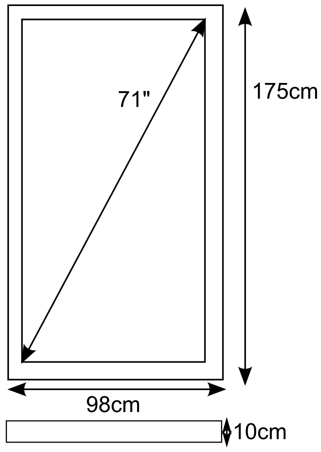
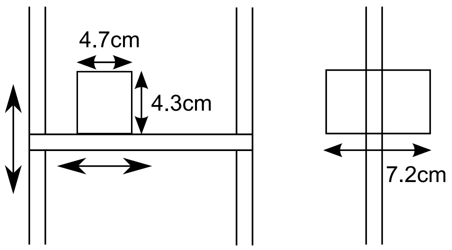
It should be stated that a High-Definition (HD) camera and screen would be used as standard, to provide the highest possible quality to the image. A 71-inch HD plasma display manufactured by LG is currently commercially available at a cost of £7400, and is currently the favoured screen technology. Other technologies, such as LCD and OLED, are not commercially viable at this size.



Model: LG 71PY1M
Display size: 71 inches
Display technology: Plasma (PDP)
Aspect ratio: 16:9
Resolution: 1920x1080 pixels

Figure 4
Schematic of LG screen

A colour HD Sony camera is commercially available for £700. The camera would be mounted on a frame which allows it to adjust its position vertically and horizontally as the user's eyes are tracked, as illustrated in Figure 5.



Model: Sony FCB-H10
Zoom: 40x (10x optical, 4x digital)
Min. working distance: 10mm (wide end) to 800mm (tele end)
Aspect ratio: 16:9
Resolution: Approx. 2M pixels

Figure 5
Schematic of HD camera (including two-dimensional motion)

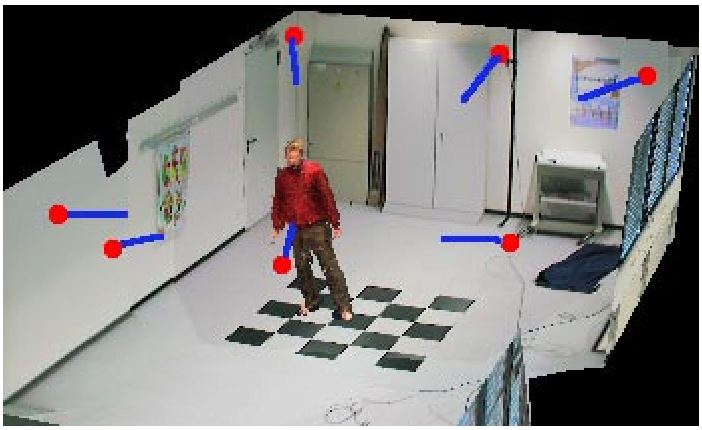


Figure 6
Approximate layout of smaller cameras[ix].
The red dots denote camera positions and their viewing directions are displayed as blue lines

A half-silvered mirror acts as a beam splitter. It allows around half the light to pass through it whilst deflecting the rest. The half-silvered mirror in the setup would allow a camera to be pointed straight at the user's eyes whilst not blocking the user's view. Providing the camera is not illuminated, the user would see the TV screen and not light coming from the camera. Intensity loss meas the room must therefore be sufficiently illuminated to ensure a full colour, good quality video feed is captured yet not so bright that the plasma screen loses effect.

The second stage in the technology, which is in fact its primary functionality, is to augment this video output with images of clothes which appear to cover the body of the user. This is achieved by analysing the shape of the user, and utilising software to fit a pre-defined image of the desired clothes onto a three-dimensional polygon shape of that portion of the user's body which is to appear altered. To aid the software, a plain and uniform background, most likely green, will cover the walls and floor of the changing room in which the interactive mirror is placed. The software may then determine the user's outline by comparison of colour to the background standard. Account will have to be taken for clothes the user is already wearing, and it is likely the software will require the user to remove particularly bulky items such as jumpers or coats. The body-shape analysis and subsequent generation of a three-dimensional polygon model would follow the method of free-viewpoint rendering developed by Carranza et al at MPI Informatik, Germany[ix] and also Eisert et al at the Fraunhofer Institut, Germany[x] consisting of seven small colour cameras (Phytec CAM-002) collocated in an elevated position around the user. The resultant seven image feeds are processed by a computer program which uses the data to produce a three-dimensional polygon model of the user. This model would reproduce the user's features; height, body size, shape etc onto which images of clothes can be mapped convincingly. This model is processed in real time and reacts quickly enough to changes in the body position to pass unnoticed by the user.

Most likely the software would simply assume a particular thickness of material of the clothes the user is already wearing and remove this from its model. In the case the user is wearing a dress or skirt, the software will be designed to recognise characteristic shapes indicating such an item and extrapolate the most likely shape of the body from the information it has.

An alternative strategy, requiring significantly less computing power, would be an analysis first of the body shape of the user, resulting in various data on the user's height, body shape etc, which can then be inputted to find a pre-existing body shape which most closely matches the user.

Figure 7

The four smaller images show subsequent video frames. The four large images correspond to *the body model as estimated by the motion capture subsystem*[ix]

One feature of this system which differentiates it from existing software developed is that the image enhancement system is mapped only over the areas which are to be altered. The remainder of the image is the direct view from the front camera. The user then sees a convincing illusion of their own reflection wearing the chosen clothes. The image enhancement system, with its multiple camera viewpoints and subsequent three-dimensional modelling, allows for the desired clothes to appear to convincingly fit the body of the user, whether loosely or tightly, depending on inputted parameters. The user's other features appear unaltered.

In both of the outlined systems above it would also be necessary to consider intermediary sections of the body or clothes below which may be displayed should the displayed clothes only partially cover the relevant area of the body (for example, an open cardigan). This would be achieved by identifying such areas as transparent when the clothes are initially inputted to the system, so the underlying clothes or skin are shown. In cases where the user wishes to display items such as swimwear, in which larger areas of bare skin are to be displayed than the user displays to the camera (i.e. it is likely they would in fact be fully clothed) then it may be possible to estimate the skin tone of the user and extrapolate an appropriate image from pre-existing data in the software. This possibility would need to be investigated during product development. Features such as this are not essential to the basic functionality of the system and would provide good candidates for future iterations on product design to be issued either as updates on hardware and/or software or through totally new product issues. However, it should also be noted that such features are likely to impress potential buyers (i.e. the large mid-to-high-end clothes stores) which could stimulate initial sales and lead to market dominance against possible rivals who may emerge once the technology becomes demonstrably viable.

Another aspect of possible features, such as that of body and skin-tone extrapolation for clothing which displays larger areas of bare skin than the user exposes to the system, is in the possibility to compliment the user. The system may display an image of toned skin, which is a best case scenario of the user's actual appearance, which remains unknown hidden under their real clothes. This is likely to boost the user's self-image, which they may associate with that particular item of clothing. Testing of this scenario, with an analysis of the reactions of test users, would be required in the development stage.

The clothes themselves would need to be inputted into the database by placing them in the interactive mirror device on a mannequin, which would be seen as transparent by the system (as it would be designed to be the same colour as the background). This would need to be done individually for each item in the store.

Required computing power

Judging from the systems described in the papers by various groups at the MPI Informatik, Saarbrucken, Germany[ix], the Fraunhofer Institut, Berlin, Germany[x], the Computer Graphics Laboratory, ETH Zurich, Switzerland[xi] and the Interval Research Corp, Palo Alto, USA[xii] the computing power required for the systems described should not exceed that provided by a high-performance computer. A top of the range desktop equipped with a Quad-Core Intel Xeon processor 500GB of hard disk space and a top of the range video graphics card should be sufficient to run the program smoothly. £2000 has been budgeted for a top of the range desktop computer.

User interaction with the system

Features for interaction between user and system would be required. This is another area where basic features could be initially released, followed by updates to the system at later dates to maintain sales after possible saturation. A number of variants are possible, and would need to be investigated by the development team. A simple manual input, placed next to the user's likely standing place, could allow the user to input commands such as calling up a desired item of clothing, perhaps arranged by colour or type and displayed on the screen itself; once the item is chosen, the screen reverts to its mirror mode of functioning. Alternatively an additional, smaller, screen could be placed to the user's side. Mode of interaction with the user's hand in this system is an area with the potential to impress – a touch pad may provide intuitive and rapid interaction compared to a keyboard. The possibility to make the larger screen itself touch-sensitive is not cost-effective at this stage, however it may be possible to incorporate interaction via the movement of the user's limbs, detected by the already-existent seven-camera detection and modelling system. By identifying particular key points, such as the hands, the system may provide a simple interaction if offering, for example, four options or fewer. The user could then point up, down, left or right to choose. This possibility would need to be researched and seems an unlikely candidate for the first iteration of the product, though it could be added later should it prove practical. Voice detection could also be investigated.

A feature allowing the customer to purchase the item once they have chosen would also be a necessity. The system could detect which size is most appropriate and perhaps send a message to one of the store assistants to retrieve the item. Alternatively the system could inform the customer exactly where in the store the item is located and they could retrieve it themselves. The customer could then pay at the desk in the normal manner.

Additional functionality

It is likely the user would wish to store particular items for future reference, and this may be allowed by the possibility of an account, which could perhaps tie-in to a store loyalty card. Accounts could be stored on a central database, allowing the possibility to compare items from different stores which have the interactive mirror product, although it is possible this idea would prove unpopular with the stores themselves. In such a case each store could hold individual databases of customers. From this database, stores could easily track users and their purchases, average spending, local store, etc, and use this data, for example, to target relevant marketing to those customers. In a broader sense stores could gain information on preferred items of clothing by analysis of the time and the frequency customers look at particular items, and perhaps alter their stock to contain more variants on particular items. Accounts could be accessed by inputting an account number or by the scanning of a loyalty card (perhaps most appealingly by utilising radio-frequency identification technology). Should face detection technology advance sufficiently, it is entirely possible that the system could recognise the user from past visits without the need for additional data. The user could then simply confirm that the system has identified them correctly. This would be a possible future development.

The possibility that customers could design their own clothes may also be considered, depending on stores and their interests for the interactive mirror product. A sufficiently complex interaction system would be required, in which the user could input their desired variants on clothes, perhaps choosing from a range of design features, colours and sizes. The final product could then be manufactured to order by the store. This feature would depend on the interest that stores demonstrate in the concept.

There is also the possibility of an interactive shop assistant, perhaps as a face appearing in a corner of the mirror screen or even a completely virtual person standing next to or behind the user in the mirror image. Testing of user's reactions to such a virtual character would be crucial to the possible success of such a feature. The virtual assistant could offer various features depending on the complexity of the software and artificial intelligence. It could offer constructive advice on combinations of clothing styles and colours, and compliment the user on their choices. Such a feature may be found to encourage customers to buy multiple items, in the way that a human assistant may encourage multiple purchases – in this technology there would be one such assistant for each customer. However, it is also possible that customers would react poorly to such a feature and research would be required. Users could perhaps choose a regular assistant stored on their account, which could adapt over time to their habits. In any case, the personality of the virtual assistant (or assistants) would likely be defined by the store depending on their market and catalogue. The development team would need to work with stores in the development of this feature. Possible use of the likeness, and even personality aspects, of celebrity persons could prove to be a marketable aspect of this feature, with licenses paid to celebrities.

All of these features could tie-in to the possible access of the system remotely via the internet. Users could logon to their account at any computer and browse clothes they have purchased or stored for later viewing. The virtual image, shown in the display of the interactive mirror, of themselves wearing the desired clothes, may be shown as an avatar frozen in a single position or possibly in a short loop of video of the user taken the last time the user entered the actual device in a store. The user may then flip between views of various clothing items for purchase later. The user may then more efficiently utilise their spare time, and enter the store knowing the clothes they desire to purchase. This could also prove to be a popular alternative in-store should the changing booth be occupied, perhaps with small (~15") touch-screens displayed outside the changing booth for such access.

Such systems clearly would require each interactive mirror device to be connected to the internet, via a secure link to a database held centrally at the headquarters of the company – which is to say, either the store owning the interactive mirror, or of the authors. The amount of data storage capacity required to store all the user information should not be underestimated and could amount to many Terabytes of data. Each mirror device could also access this database to retrieve information about customers as they enter a device, or if the customers access the database remotely from a computer then relevant computer protocols would also be required for that case.

Cosmetic surgery

An alternate functionality of the system which could prove to be successful is in its application to the cosmetic surgery industry. Customers would stand in front of the mirror device and, instead of clothes appearing, a prediction of the results of surgery could be superimposed over whichever part of their body is to be altered. In this technology, the user would be required to stand in front of the mirror displaying the bare skin of the affected region. The display would then, in a manner similar to that already outlined for clothes, use its database to estimate the appearance of that region after a successful surgery. Patients are likely to appreciate such a direct and visible view of their possible new body, and clinics would be likely to purchase the item in the hope that more people will commit to surgery after such a consultation.

Other possible applications would include any image-alteration industries such as opticians, tattoos and hairstyling, though the cost of manufacture would need to fall before such industries are likely to be inclined to pay for such an item. However it may also be considered that such applications are likely to require only a small screen in comparison to the full-size model (perhaps 15”) and so cost may be lowered fairly significantly.

Conclusions

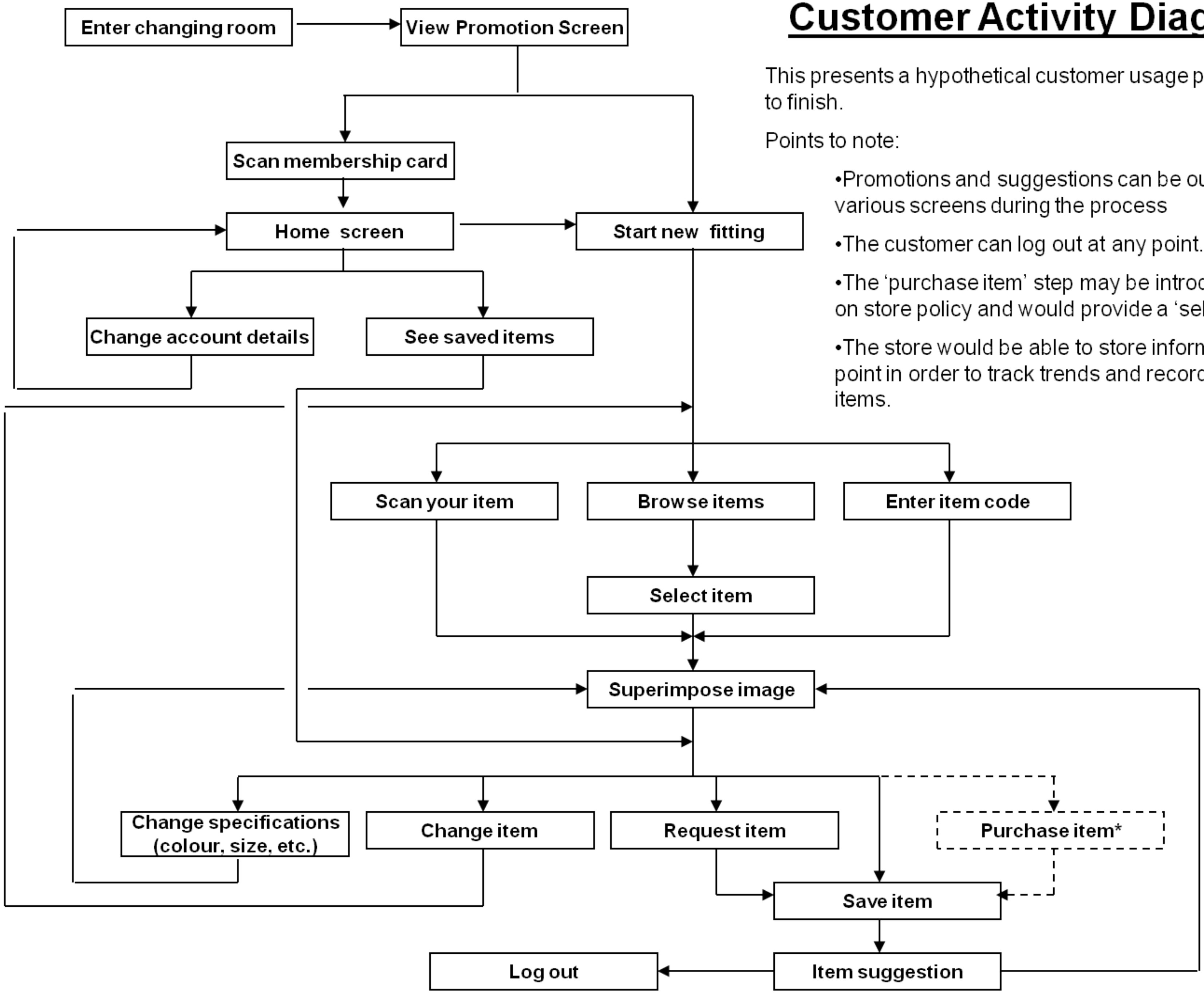
Although the necessary image alteration technology largely already exists, it does not in the exact form required and fairly significant programming skill would be required to form the system. Collaboration with teams which have already developed systems would be required in order for the product to be developed within a reasonable timeframe. The interaction software and virtual shopper software would also need to be developed with collaboration from existing teams. Other technologies, such as the screen and the camera, are commercially available and could be utilised by the development team with no delay.

Customer Activity Diagram

This presents a hypothetical customer usage process from start to finish.

Points to note:

- Promotions and suggestions can be output onto various screens during the process
- The customer can log out at any point.
- The ‘purchase item’ step may be introduced depending on store policy and would provide a ‘self-serve’ option.
- The store would be able to store information at any point in order to track trends and record most viewed items.



3. Costing

The product is an opportunistic idea that needs to enter the market as soon as possible in order to gain an advantage over any potential competitors. As such, we have set a target for the conception-to-market-entry time at 3 years. This target is ambitious but achievable and will be made possible by our distinctive funding plan. Our business plan will be entered in the Imperial College Business Plan Challenge in February, which has a top prize of £25,000 in cash and business assistance. Winning would provide an initial cash injection with which to secure initial funding and prepare our plans fully.

The process will be split into two stages: Stage 1 will last for one year and will consist of setting up the company premises, developing links with suppliers and investors, and developing a prototype of the product. We will seek to fund this stage be offering an angel investor or venture capital firm 10% equity of our business for a fixed lump sum, detailed later.

Stage 2 will last for 2 years and consist of exhibiting the prototype(s) to potential investors, further research and development of the product and manufacturing an initial batch of the product. Our company will seek funding at this stage by courting large fashion retail chains in a large, developed market place such as the EU, USA or Japan. We will sign a 3 year exclusivity deal with the retailer, giving them exclusive purchase rights to our product for 3 years in exchange for funding and business assistance. Such a model has been shown to work on a similar yet basic product for the show market, funded exclusively by adidas[xiii].

This deal would involve a guaranteed number of unit sales and all marketing/advertising would be the sole responsibility of the fashion retail chain, lowering our costs. The plan's lower level of reliance on traditional sources of investment such as venture capital funds would hopefully nullify the effects of the global "credit crunch" on our chances of finding funding.

When the Stage 1 funding has been secured, our company can start to recruit the first wave of employees. Our team currently consists of 6 individuals: 1 of which has had relevant industrial experience in the electronics industry and another is talented and experienced programmer. In addition to their skills, we will recruit 2 experienced software engineers, 2 experienced electrical engineers and a consultant manager/managing director with a strong background in guiding hi-tech start-ups.

The average wage for the 3 electrical engineers will be £60,000 per annum plus 105% overheads and the average wage for the 3 software engineers and 5 management staff will be £50,000 per annum plus 105% overheads. The specific wages of the individuals have not been calculated in order to leave us some flexibility in the wage structure with which we will be able to attract the highest calibre of staff. Our wages will be lower than the consultants as we will each initially own $1/6^{th}$ of the company's equity and will receive profit dividends. In order to increase productivity, bonuses may be paid to the other staff members upon successful achievement of targets such as securing Stage 2 funding. However, this has not been budgeted for as yet and would need to be assessed at the relevant stages.

Company premises would be sought on the outskirts of London in order to minimise costs and tap into the highly skilled work forces that exist in areas where other high-tech and electronics companies operate (M4 Corridor near Reading, Guildford/Crawley in Surrey etc). We would rent out a business unit in a warehouse/office style with a budget of £50 per square foot: requiring 200 square feet per office employee and 600 square feet for the electrical engineers (2,800 square feet in total). PCs and peripherals for each member of staff would average out to £1,100 and £30,000 worth of tools and equipment would be provided for the electrical engineering workshop.

Intellectual Property (IP) will be the company's main asset due to the nature of our business and it therefore must be protected at all costs. The small size of our business will aid in this, as the "IP leakage" will be able to be monitored very easily. All staff will be asked to sign non-disclosure agreements before they work for the company, giving us a degree of protection from this risk. Patents will be filed in all of our target markets (EU, USA & Japan) in addition to countries where competition and imitation will be likely to appear (China & India). Any brand identity that is created for the product will also be protected by obtaining trademarks and copyrights in the relevant countries.

It is estimated that the total cost for the product components will start at £13,900 per unit (see figure below). However, the prices quoted are the retail prices of the relevant products: as our company grows and our production volume increase we aim to set up links with the manufacturers and secure supply deals resulting in the component prices being lowered significantly. It is said that a good guide for the sale price of a technology product is π x cost to build, which mean our product retailing at £44,000. Rounding up to £50,000, this would be a fair price for the device as it would require the sale of, say, 500 dresses at £100. Assuming that 1 dress would be sold per day, it would take less than 2 years for it to be paid back. Even this extremely conservative estimate shows that the device would be very cost effective for the retail industry.

The total cost of the prototype is highly dependant on the software price. Our three engineers will be highly skilled and should be able to construct a basic working model of the 3D imaging software within the Stage 1 timescale. We had previously budgeted £0.8 million for this phase; however, it seems possible that we will have to purchase a licence on certain parts of the software solution in order to speed up development.

Labour	Per Capita	Quantity	Overheads	Total
Electrical Engineers	£60,000	3	£189,000	£369,000
Software Engineers	£50,000	3	£157,500	£307,500
Management	£50,000	5	£262,500	£512,500
Total	£160,000	11	£346,500	**£676,500**

Financial Services	Total
IP (Trademarks, Copyrights & Patents)	£25,000
Financial Services	£40,000
Insurance	£10,000
Total	**£75,000**

Components	Per Unit	Quantity	Total
Display Screen	£7,400	4	£29,600
Cameras	£3,000	4	£12,000
PC	£2,000	4	£8,000
Green Screen	£500	4	£2,000
Half silvered mirror	£500	4	£2,000
Interface/Controller	£500	4	£2,000
Total	£13,900	24	**£55,600**

Premises	Total
Office Rental	£81,800
Tools/Equipment	£30,000
Computers etc	£12,100
Utility Bills	£5,000
Consumables	£5,000
Total	**£133,900**

Contingency	Total
Contingency Funds	£97,700

Software	Total
Software Licenses	£400,000
Total	**£400,000**

Total Expenditure	**£1,438,700**

Chart 1
Basic costs sheet for Stage 1 (prototype build phase)

Software packages that may need to be licensed include the 3D imaging software model used by Eisert *et al* in the adidas shoe mirror mentioned earlier, the customer profiling and recommendation software used by Amazon and the search algorithms used by Google. Thus we have allotted an extra £0.4 million in order to take out trial licences on software should it be deemed necessary.

After some minor readjustments of other costs and an extra £0.1 million contingency fund to cover equipment and components, the total funding required to build 4 prototypes and therefore complete Stage 1 is **£1.45 million**. This will be sought from angel investors and venture capital funds, as already stated.

The initial cost per unit will be comparatively high until we secure deals with suppliers and lower the component costs. Also, the manufacturing is likely to be very expensive if carried out by our 3 electrical engineers alone. Looking at the figures below, it becomes apparent that to build the mirrors at a fast enough speed to break even over the year the build and test time will need to be reduced to 87.5 hours (just over two weeks per unit).

Components	Per Unit
Display Screen	£7,400
Cameras	£3,000
PC	£2,000
Green Screen	£500
Store Card Reader	£500
Interface/Controller	£500
Total	**£13,900**
Approx Price (costs x Pi)	£43,668
Electrical Engineers	3
Hours per week	37
Weeks worked per year	48
Total build hours per year	**5328**

Calculations	Per Unit
Assembly time per unit	67.5
Test time per unit	20
Packaging Time per unit	5
Total build time per unit	92.5
Amount of units made per year	58
Material costs	£800,640
Income from units @£50,000	**£2,880,000**
Income after 1 year	£2,880,000
Total Expenditure after 1 year	£1,438,700
Total Profit after 1 year	**£1,441,300**
Profit	0.2%

Chart 2
Unit cost estimates (built by 3 electrical engineers)

To make profit, the build time would have to be reduced significantly below this level. Assuming a fixed testing time of 20 hours per mirror (for CE, Kite mark, fire safety, sensitivity and functionality checks), the profit as a percentage increase in the expenditure against the build time alone is detailed below. The group would have to aim for 37 hours build time per unit to hit approximately 100% return on outgoings, taking the total time of each unit to just under 2 weeks.

Our system should be relatively easy to assemble and two weeks may be a reasonable target. However, this would result in about 100 units being manufactured per year. In the short term this maybe viable but in the longer term it would not be an efficient manufacturing process. We must seriously consider outsourcing the manufacturing process to a factory with the relevant skills, or undergoing considerable expansion of the company after the four year mark in order to hit reasonable price levels.

The major potential pitfall with outsourcing the manufacturing process is the loss of IP, because another company will be physically assembling the product and we will not be able to guarantee the access to the design specs etc. This could be reduced by finding a reputable company and signing deals with them, guaranteeing loyalty and mixing in our interests with them (i.e. exclusive manufacturing rights over a certain period of time, non-disclosure agreements). However, it is worth noting that the main IP generated will be in the software area and the manufacturing contractor will have no input in this sector, other than to load the software package onto the computer. Therefore this may be the more viable option of the two and should be explored.

Targets for production and income can be found in the chart below, also detailing the return of the Stage 1 investor who would receive 10% of income. This very basic model assumes a large and expanding market, in addition to sustained growth in manufacturing capability that would be able to reach a peak of 2,500 units annually by year 8. It also assumes expenditure will be fixed at 15% of total income, which is not unreasonable to be taken as a rough guide.

Year	Predicted Sales	Predicted Income	Predicted Profit	Stage 1 Investor Return	Stage 1 Investor Return percentage
1	0	£0	£0	£0	0%
2	0	£0	£0	£0	0%
3	50	£2,500,000	£2,125,000	£212,500	15%
4	100	£5,000,000	£4,250,000	£425,000	29%
5	250	£12,500,000	£10,625,000	£1,062,500	73%
6	500	£25,000,000	£21,250,000	£2,125,000	147%
7	1,000	£50,000,000	£42,500,000	£4,250,000	293%
8	2,500	£125,000,000	£106,250,000	£10,625,000	733%
Total	**4,400**	**£220,000,000**	**£187,000,000**	**£18,700,000**	**1290%**

Chart 3
Projected unit sales, income and Stage 1 investor return

It is clear that the Stage 1 investor can expect to receive £18.7 million in dividends after 8 years, which is a substantial profit on their £1.45 million investment (greater than ten-fold return). The return of the Stage 2 investor is not predicted by our business model as it would be strongly dependent on in-store factors such as advertising, customer profile, product nature of the retailer, etc. We estimate, however, that the product could potentially yield a 20-40% increase in sales, in addition to marked increase in customer satisfaction and brand image.

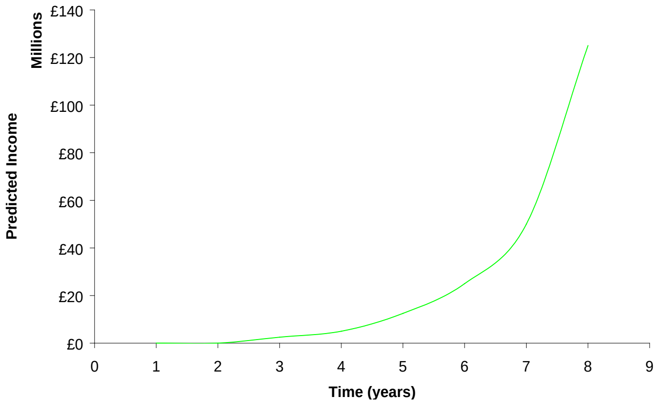


Chart 4
Projected income vs time

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