Analysis

Problem Identification

Currently there is no way to interact with a computer using motion controls without purchasing specific hardware to do so. Motion control has many benefits ranging from educational purposes (for both young students using interactive learning tools, and the elderly who may not be comfortable with using a computer traditionally), to hand muscle rehabilitation through gestures. Motion control can also be used to interact with games in new ways for entertainment.

The features of a computer system that would be required for this solution would a computer with hardware capable of image processing with computer vision, a webcam and a suitable operating system for the software to run on. The problem lends itself to a computational solution because it would be interacting with a computer. Describing it in its simplest form, the solution would take a picture of the user with the webcam, and the software would then identify the hand location and move the mouse cursor to that location, and even could perform other commands.

Stakeholders

The clients and demographic for this software would be users of a computer. Because of the range of applications for motion control the stakeholders will be a representative sample, ranging from older people who struggle with using computers, to gamers who are very familiar that would be able to test it in different circumstances.

The stakeholders for this software represent mostly casual gaming, but there are also people representing accessibility and educational games.

A large amount of casual games can be played using just the mouse and its buttons. Examples of these games are 'Sid Meier's Civilisation V' and the 'Sims' series. These games lend themselves to this software because it will mainly control the mouse movement with the option to add bindings to different actions. The stakeholders for the casual gaming demographic are Ryan Carver and Oliver Gill. Both are experienced gamers that both like casual gaming, especially with titles such as 'Sid Meier's Civilisation V' that will work with this software.

Another type of games that will be appropriate for this software is educational games for younger children where the gameplay relies on interaction and drag and drop mechanics. Allowing them to control the game with gestures can keep them interested in the game and learn for longer. The stakeholders for this area are Sarah Robson and Jon. Sarah is a tutor that has experienced working with small children in a classroom environment where they play these types of educational games. Jon is a five-year-old who is currently in year one, and he would be using this software to interact with the games.

Why it is suited to a computational solution

This problem lends itself to computational methods of finding and implementing a solution for a variety of reasons. The solution will be software that uses a webcam to detect motion and gestures. This will need to run on a computer simply because that is the environment in which the motion control will manipulate, and a computer is needed for the webcam. There is no alternative to solution that would not require a computer.

The aspects of the solution that would be controlled by the computer mainly is the webcam recording the user to gather data about where their hands are. The software would then process the image to identify where the hands are, and using this location move the computer's cursor.

Computational methods that the solution lends itself to:

Problem recognition:

The overall problem is finding a way of translating hand movement into mouse movement, whereas the actual underlying problem is being able to identify a hand when provided with an image of the user. When this is overcome the rest of the solution is simply applying the information about where the hand is to another task, in this case moving the mouse. If gestures are involved then not only does the hand need to be identified, but also contoured in a way that gestures can be recognised.

Problem decomposition

This problem can be decomposed into a set of much smaller steps. This is an initial idea of what these steps are:

1. Using the webcam take a picture of the user.
2. Apply a colour filter to identify the location of skin in the image.
3. Using computer vision contouring identify the hand and its location in the image.
4. Using this location, move the mouse of the screen.

When this is done, the process is completed, and it is done fast enough that there is no lag. With computer vision the computer is not normally looking at a video, it is looking at a set of still images and processing them quickly one after another.

Divide and conquer

These smaller steps challenging on their own, but very doable. Solving these steps on their own and then combining them into a modular program makes use of the divide and conquer method of problem solving.

Abstraction

When identifying the hand in an image of the user abstraction is used. An image contains a huge amount of data, almost all of it we don't need. A blur is applied to limit the variation of colour change in a small space. A mask is then applied to delete everything that is not skin coloured, as it is not needed.

The output of the program will be the mouse movement, meaning that overall the software will provide a means of controlling the computer without using the keyboard or mouse directly. This allows a different kind of experience for interacting with the computer that would benefit education games where the interaction would help the child to not get board of the program. It could be used for interacting with casual games for any age of gamers that want a different kind of experience with the game.

Interview

Interview questions

I will outline some of the key questions that I will ask each stakeholder, but during the interview I may ask follow up questions or ask them to elaborate on certain answers. The questions will find their opinion on the software and how they would like to use it.

Casual gaming

My questions for Ryan and Ollie (who represent casual gaming) are as follows:

1. Are you satisfied with your current casual gaming setup?
2. Have you ever experimented with motion controls?
3. If yes, what was your experience and how did they enhance the game?
4. What do you think of using your hands in the air to control the game?
5. How would you like the software to be operated?
6. How would you like to use your hands (gestures etc.)?
7. Do you have anything else to add?

Questions one and two establish their history with gaming and using motion controls. This is important as it is necessary to know if their opinion is based on previous motion control experience or not.

Question 3 investigates any issues they may have had with motion controls if they had used them before, or what make the motion controls successful and fun to play.

From question 4 the questions start to ask about this software. Question 4 asks if they are happy with the main control system of this solution (motion control with moving your hands in the air).

Questions 5 and 6 investigate the usability of the software and how they would like to control it, focusing on both the user interface and the motions that they would have to perform.

The questions conclude with asking if they have anything to say that may have been missed.

Educational

Questions for Sarah (a tutor):

1. Do the children you work with use educational games?
2. If yes, what are the main controls of the games?
3. Do you think children would like motion control?
4. Do you think children would benefit from using motion control?
5. How would you like the software to be operated?
6. What gestures would the children be able to do?
7. Do you have anything else to add?

Questions one and two identify what she thinks are the main aspects of the games that the children use. This can be used when designing what the software can control so that it is compatible with these games.

Questions three and four ask if the children would like to use the motion control in the games, and more importantly whether it would be of use to them for learning, or whether it would just be a distraction.

Questions five and six ask how she would like the software to be operated, considering that children may be difficult to work with if calibration is needed. Questions six asks what gestures the children would be able to do, considering that they would be less able to perform complex gestures and would need more pronounced movements. They might also not be able to remember a large set of gestures.

Questions for Jon (a child):

1. How often do you play computer games at school?
2. Do you enjoy playing them?
3. Would you like to be able to play them by controlling the computer with your hands in the air?
4. What hand movements would you like to do?

These questions are designed to get a feel for how a child would react to this software, and if they think it is a good idea. Because of his age, Jon may not be able to give useful feedback about how the software could work, so instead these ask what he would expect for hand gestures (indicating what gestures children are able to perform).

Interview

Casual gaming

Ryan

1. **Are you satisfied with your current casual gaming setup?**

"Yes, I'm more than satisfied. I've got dual monitors, a mechanical keyboard, and a fancy mouse with loads of buttons, and a headset. I play casual games once a week."

2. **Have you ever experimented with motion controls?**

"Yes I have, I've used the Nintendo Wii that has motion controllers to play the games, but I have not used motion control with my computer."

3. **If yes, what was your experience and how did they enhance the game?**

"The motion controls were not great, you have to calibrate and sync the controllers. I found that it was limited because you had to move in a confined space and could hit things with the controllers. They made the games more accurate and immersive as what you do translated to what happens inside the game, which gives you a form of freedom that you would not get from buttons."

4. **What do you think of using your hands in the air to control the game?**

"If you only use hands to move the cursor it would be a bit limited, more controls would be needed, like using gestures. It seems more like a gimmicky way to play games and does not look viable in terms of playing the game well (like competitively), but would be fun"

5. **How would you like the software to be operated?**

"I would like to be able to turn on the software and have it to work straight away. I would like the option to customise the controls so that I can change gestures to work with different games."

6. How would you like to use your hands (gestures etc.)?

"Different finger movements and different hand positions. Not everything should be static, some gestures could involve movement. I do not want to feel confined by this, so that I can be further from the screen. Because of this I would like to know when my hands are in the camera's frame, so maybe a pop-up could warn you when you move outside the frame."

7. Do you have anything else to add?

"No, I think I have shown what I want."

Ollie

1. Are you satisfied with your current casual gaming setup?

"I think so, I currently have a desktop computer which I control with a keyboard and mouse. Most of the time I play casual games like the Sims, and I mostly use the mouse."

2. Have you ever experimented with motion controls?

"Not yet, but it is something that I plan on looking into. Using motion control would be an interesting way of controlling the games."

3. If yes, what was your experience and how did they enhance the game?

Ollie has not used motion controls before.

4. What do you think of using your hands in the air to control the game?

"Using hands would be a good way of controlling games as you would not need a controller which can be uncomfortable. Because it uses a webcam, something that I already own, I would not need to but an expensive controller. I like the idea."

5. How would you like the software to be operated?

"I'm not very good with setting stuff up, so I would need it to be very simple. It would need to explain what I have to do to control the computer, and what I need to avoid like moving where the camera cannot see me."

6. How would you like to use your hands (gestures etc.)?

"Simple gestures would be better because I do not want to have to remember lots of complicated gestures. I am used to using a smartphone so having similar gestures like pinch to drag would be useful."

7. Do you have anything else to add?

"With consoles when the controllers run out of battery it breaks the game's immersion, and I think this software might have the same affect if it loses where your hands are, so it would need some good calibration so that this doesn't happen."

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Analysis

Neither of the casual gaming stakeholders have used motion controls with their computers. Ryan had used motion controls with consoles, with his primary complaint being the constant calibration that the controllers needed, and how they could hit objects around him while playing. The solution would need a robust calibration system that would mean that you would not have to constantly re-calibrate the software. Because there are no physical hand held controllers for this, there is no risk of them hitting objects like monitors.

Ryan pointed out that there would need to be a range of controls needed to play most games, and so gestures could be used to activate different key presses (for example making a fist to click the mouse). This implementation would need to be not very complicated, as it may become difficult to set up (as pointed out by Ollie). There needs to be clear instruction on how to set up the software, and an explanation of what you can and can't do.

Educational games

Sarah

1. **Do the children you work with use educational games?**

"Occasionally, yes. They are used as a reward for the children, so we try not to use them too often, we use them a few times a week normally."

2. **If yes, what are the main controls of the games?**

"The games are click based, meaning you click on what you want to do or where you want to go and the games that com up are all controlled by the mouse. Because of this we normally use a touch screen white board and let the children play."

3. **Do you think children would like motion control?**

"I think they would. They love using the touch screen whiteboard, and I think it helps them to stay interested in the game. Motion controls would have the same effect on them, it would make it more fun and interesting, as long as they don't get in the way of the game."

4. **Do you think children would benefit from using motion control?**

"I think so, it would help them to stay interested in the game and the learning. I wouldn't add much to the game as it can be played fully without motion control, but it would make the overall experience for the class fun."

5. **How would you like the software to be operated?**

"It would need to be very simple to use, so we do not spend too much time setting it up or working out how it would work. If the children are using it then it would need to be easy to connect to them [calibration]."

6. **What gestures would the children be able to do?**

"Nothing too difficult, only basic things like making a fist, making their hand flat or pointing their finger."

7. **Do you have anything else to add?**

"Not really, I think it would be good so long as it works well and the children don't have difficulty using it."

Jon

1. **How often do you play computer games at school?**

"Every week. We play more if we have been good."

2. **Do you enjoy playing them?**

"Yes, they are very fun. Most of the time we have to watch each other play, but I like playing them more. They are one person at a time games."

3. **Would you like to be able to play them by controlling the computer with your hands in the air?**

"Yeah! It would be like magic!"

4. **What hand movements would you like to do?**

Jon pointed with his index finger and waved it around the screen, saying that that is how he would want to move things. He also made a fist to pick things up.

Analysis

For educational games aimed at children the controls that they need to use are very simple, normally drag and drop, clicking etc. The children also would not be able to make complicated gestures, only making fists and pointing their fingers. Calibration would have to be very easy for the teacher to do so that the child can use the software.

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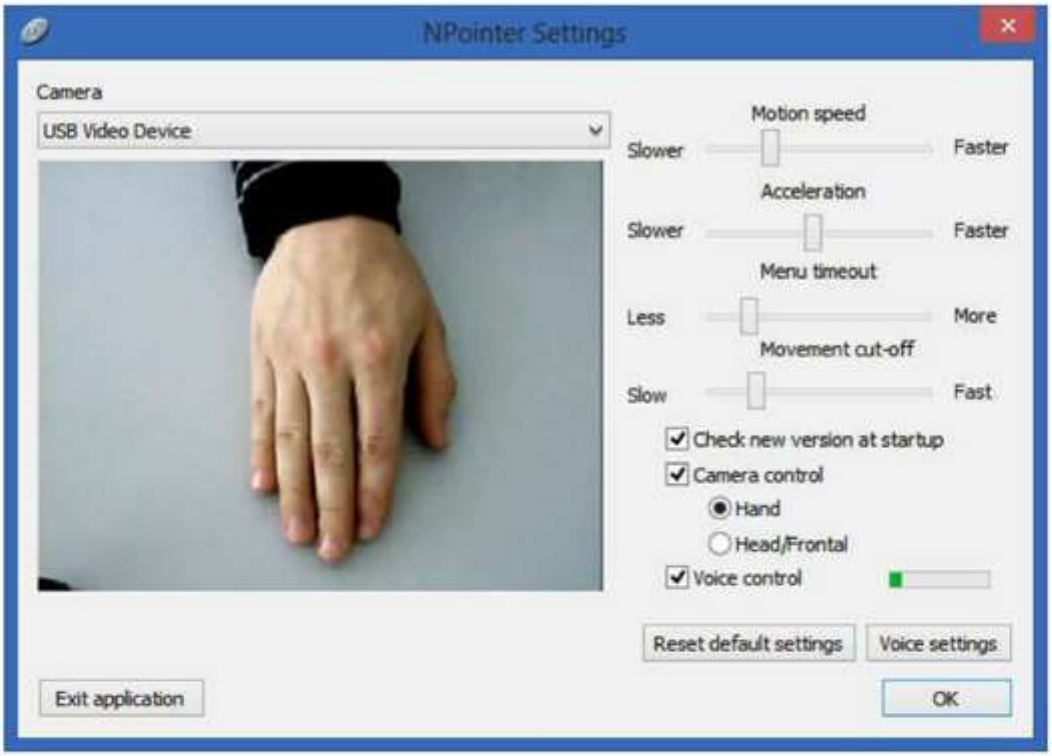
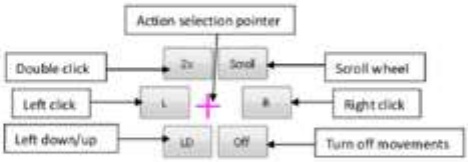
Research

Existing similar solution

NPointer

Overview:





NPointer has an 'action menu' pop-up near the hand.

NPointer is a free gesture control program for Windows XP and higher. Using the webcam and microphone you can control the mouse and other parts of the computer. They recommend using this with a webcam pointed down at a flat surface and then using your hand like you are using a mouse. It also works with the webcam pointed at the user, but can have interference with face detection, and favours using the face to control the mouse instead of the hand, which I found to be inconvenient. The user interface is very simple, consisting only of a window showing the webcam feed with limited menus with sliders that control the movement speed of the mouse and other settings. I found these settings to be lacking as I could not specify some things like gestures.

Parts that I can apply to my solution:

The concept of NPointer is similar to my solution, but my solution will have more of an emphasis on its applications. The window showing the webcam feed was very useful for me to set up the camera so that my hands could be seen, although if I used this in my solution I would have an overlay showing an outline of the hand or something similar to show what the software is gathering from the webcam image. Some of the settings were easy to change, particularly the sliders. The program

seemed lightweight and fast to open and the window was small and did not get in the way, something that I would like to carry forward to my solution.

Flutter

Overview:

Flutter is a gesture control program that focuses only on gestures (no hand tracking) to control the user's media. An example of how someone would use this is to sit in front of their webcam and make a sweeping gesture, indicating t the software to change the song playing. It has support for Windows Media Centre, and other media locations like YouTube. It worked well most of the time, however I found it more of a gimmick and not useful as it only controlled a limited number of things. Media control on its own did not seem like enough to make the software worthwhile. However, it did have good and easy to follow instructions.

Parts that I can apply to my solution:

My solution will also use a webcam to detect gestures, although this is more of a coincidence than something that is inspired by Flutter. The instructions were very clear and simple, consisting of a few images in a slide show format as you open the application. I think that having simple instructions will benefit my solution greatly, especially if I end up implementing a calibration screen.

Leap Motion

Overview:

The Leap Motion is a piece of hardware that used infrared light to detect the location of your hands in a 3D space. This can be used to control games in a 3D way, where your hands can be recreated on screen. The main emphasis of this product is that it detects depth with hand tracking, something that makes it unique. There are many third part applications that use this hardware ranging from games, to accessibility software resembling the software that I will be creating. Some applications allow the Leap Motion to be used to control the mouse of the computer so that it can be used to control any part of the computer, which has many uses for people with accessibility requirements.

Parts that I can apply to my solution:

One of the main purposes of my solution will be that it uses the webcam and has no need for any proprietary hardware, so the leap motion is not very applicable to what I need, as it is a piece of hardware. It gives the impression that it is more of an enthusiast grade product as setting it up is not very straight forward. Despite this I would like my solution to recreate the feel that the Leap Motion has when using it to control the computer.

Intel Realsense 3D Camera

Overview:

The Intel Realsense 3D Camera is a camera that has two parts to it, a traditional camera, and an infrared camera. The infrared camera allows the camera to see depth instead of just a two-dimensional image, opening it up to a range of motion control applications. Support for this camera is mainly in the form of interactive educational games and less so in general computer control.

Parts that I can apply to my solution:

Although the Realsense 3D Camera is a webcam, it is not commonly found in computers and so I would count it as separate hardware that you would need to go out of your way to buy to use, and so it falls into the same category as the Leap Motion. The educational games that are compatible with this camera give an insight into the types of games that could be used with my solution.

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Touch Screens

Overview:

Touch screens are a type of screen on a computer that allows the user to touch the screen and move the mouse. Windows has built in touch screen support, so they can be used with any Windows application. They are becoming very common on laptop and all-in-one computers (computer that have the main computer and the screen attached into one item). They allow gesture control via built in windows support. They can be great for motion control, especial with operating systems that were built with that in mind (for example Windows 8).

Parts that I can apply to my solution:

Touch screens are not applicable to my solution as they provide motion control but in a different way that what I need. My solution will never include touch screens as a form of input as any computer that has one already has gesture support.

Steelseries Sentry

Overview:

The Steelseries Sentry is a piece of hardware that tracks the users eye movement and moves the mouse accordingly, or performs another relevant action depending on the application. It is meant for use in gaming with genres such as racing games where you can steer by looking at where you would like to go. It is an expensive piece of hardware that uses USB and drivers. The calibration screen has lots of dots that you stare at to train it to lock onto your eye's gaze. The calibration user interface is simple to follow.

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Parts that I can apply to my solution:

The Steelseries Sentry is very similar to my solution in that it is a means of controlling the computer without using a keyboard or mouse, and moves the cursor. However, this is designed to work alongside the keyboard and mouse offering people another way to control the computer. It is a separate piece of hardware, which is what I am trying to avid in my solution (apart from generic webcams).

Features of the proposed solution:

Initial concept of my solution considering this research:

My solution will be an application that when started will bring up a simple set of instructions that are easy to skip if necessary, and when open will have a window showing the image that the webcam can see along with an overlay showing what the software can identify (hands or face, etc.). It will have a simple set of sliders that can control basic settings like mouse speed, but will have the option to change some more advanced settings. The software will use the image captured by the webcam to work out where the user's hands are and move the mouse accordingly so that they can control the computer hands-free.

Limitations of my solution:

The main limitation of my solution will be that it does not detect depth, making any gestures limited. It cannot detect depth because it is using a webcam to gather image data. Theoretically it could work out depth using the principal of if the hand is smaller it is further away, but this would be difficult to implement and unreliable.

Another limitation of this solution would be your immediate environment. If you are in a simple, well lit room the software would work well. However, if you are in a busy environment it may be harder for the software to determine where your hands are, and if the lighting is constantly changing (like if you are outside and the sun goes behind the clouds) then it may find it hard to keep tracking the hands.

Further meeting with stakeholders:

This is an email that I sent to my stakeholders (Ryan, Ollie, and Sarah):

"Hi,

I've been looking at ways that I can make the software and have come up with some specific ideas of what it could include, and I would like your input. When the software starts, it will have clear instructions of how to calibrate it (involving making sure you are in the camera image and clicking 'next', nothing technical). When this is complete it will bring you to the main screen of the application (which is a small window intended to be tucked away in the corner). From the main screen, you will have the option to calibrate it again, start and stop the mouse tracking, and have access to simple settings such as the mouse speed. The software will be designed to look neat and will be easy to use. So far it looks like the system requirements will include a fairly capable computer, amongst other software requirements.

Thanks,

David"

These are the responses that I received:

Ryan:

"That sounds good! It has all the basics needed for me to use the software. My computer is a gaming computer, so it is more than capable of running this software. I will probably have the software minimised or hidden behind something else, so the design is not a worry for me, but I like the sound of a simple look for it."

Ollie:

"The calibration sounds complicated, so as long as it is easy to do I'll be okay with it. Maybe have some written instructions with it to tell me what to do if I can't work it out? My computer will probably be able to run this, but if it had an option to reduce the processing power the program needs that would be good."

Sarah:

"I'm pleased that the calibration will not be difficult if I am trying to calibrate it to a child! Other than that, this sounds promising. I definitely like the option of changing the mouse speed"

Requirements

Software and hardware requirements

Hardware

A computer capable of running the software, with standard IO peripherals – The software will use the webcam and will use computer vision to analyse the image. A computer with a fast enough processor is needed. Most laptops and desktop computer are capable of this. The standard peripherals include a monitor, keyboard and mouse for navigating the software.

Webcam – A webcam is used to take a video of the user, which will then be analysed to locate their hands. The webcam needs to be of sufficient resolution (around 480p or higher), the higher the resolution the better. If the resolution is very low then when the user moves their hands the mouse may move less smoothly, or jitter.

Software:

Windows, Linux or Mac operating system – These are the operating systems supported by both Python and OpenCV (the computer vision library used to analyse the images).

Python interpreter – The code will be written in Python, so a Python interpreter is needed.

OpenCV for Python - This is the computer vision library that I will be using. It allows simple and efficient analysis of images. This is important for detecting hands.

Numpy for Python – This is a library for python that is used with OpenCV.

Stakeholder requirements

Design

Requirement	Explanation
Simple main window with the webcam feed shown	So that the user can adjust their camera and see what the program 'sees' with hand detection
Lightweight design	The design needs to be simple to sue and not too confusing to use
Clear instructions with diagrams	There needs to be calibration instructions, and images would make this clearer
An obvious way of stopping the mouse movement (like a button or text saying which key to press)	If the user cannot control the mouse properly they need a clear way of stopping it being controlled via the camera
A simple calibration process	The calibration needs to be simple, so the user can just click 'next' and won't have to do anything complicated.

Functionality

Requirement	Explanation
Use of webcam to move the mouse	This is the main function of the program, using the webcam so that you can control the computer's cursor by moving your hands.

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Simple and easy calibration	Because users that may not be familiar with setting up software could be using this a simple calibration is needed so that even children can calibrate it.
A stop button to regain control of the mouse	If the hand detection goes wrong the mouse may start moving too much, so a stop button is needed so that the user can regain control of the mouse and close the program.
Changeable controls linked to gestures, namely a gesture to click the mouse	A set of gestures needs to be mapped to different controls for different games, and for children using the computer who may only be able to do simple gestures, some must have to option to be disabled.
Calibration instructions, and instructions on what you can and can't do when using the software	Instructions are needed to make the calibration process easy to do. Instructions on what you can and cannot do are needed to show the user things like they cannot move their hands outside of the frame.
An option to change the mouse speed	So the mouse can be sped up to be more sensitive, or slowed down to be less sensitive
A settings menu and an information menu	A settings menu that contains all the settings that is in a separate window, and an information window that explains how to use the program and how to calibrate it

Hardware and software

Requirement	**Explanation**
Standard peripherals: Computer with a keyboard, mouse and monitor	The user needs a basic computer to use and navigate the software. The computer must have standard items such as storage and a processor. The program size will be less than a gigabyte.
A USB webcam that is at least 480p	The webcam is used to image the user. The higher the resolution, the smoother the mouse can move.
Computer specs: **[enough to run the software, amend this later]**	The computer needs to be able to run some image processing.
Windows, Mac or Linux operating system	These are the operating systems that are supported by Python.
Python with OpenCV, Numpy and Tkinter	The program will run on Python with OpenCV, which uses Numpy. Tkinter will be used for the user interface.

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Success Criteria

Criteria	How to evidence
Main window that shows webcam feed	Screen shot of main window that shows the webcam feed
Webcam feed shows what the computer 'sees'	Screen shot of the camera feed with image processing overlays
Simple, lightweight design.	Screen shot of the window with large buttons, with the main window not too cluttered. A large and easy to navigate to calibration button
A simple, non-technical calibration	Screen shot showing the calibration with simple instructions and 'next' buttons
A large stop button with colour showing if the program is running	Screen shot of the button with different colours depending on the state of the mouse
The option to press a button to stop the program	Showing the code that facilitates this, along with testing evidence.
Text that shows which button this is	Screen shot of the text on the main window
A settings menu in a separate window	Screen shot of settings button and it's window
The option to change the push to stop button	Screen shot of this option, and code and testing showing that it works
The option to change the mouse speed	Screen shot of this option, and code and testing showing that it works
A low processing power mode for lower-end computers	Screen shot of this option and show the CPU load reduction when this mode is switched on
The option to set gestures	Screen shot of this option and code and testing showing that it works
An information menu in a separate window	Screen shot of information button and its window
Text explain how to use the software and a link to calibration instructions	Screen shot of this text and button
Clear, picture based calibration instructions	Screen shot of these instructions

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Instructions easy to find	Screen shot of large buttons that navigate to these instructions, no more than two clicks from the main menu
Moving the hand causes the mouse to move	Evidence of testing that this main feature works