Sailing Simulator

H446-03 | Joseph Henderson - 2073 | Wren Academy - 12258

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Todo:

- Write section about the analysis I've done on my Survey

- Add in last stake holder once they have finished answering my questions
    - Reasons for why each stakeholder and why this is the a good colution
- **Finish Why the problem can be solved by Computational Methods**
- Bibliography
- Measurable success criteria in terms of 'functionality", 'usability' and 'robustness'
- Approach based on research of existing solutions
- Explanations of what's
    - essential features, what's not,
    - described and explained
    - Limitations of each
    - Inputs and outputs

Analysis

Problem Identification

I want to make a program to practice sailing tactics, analyse your own decisions versus others and to know what the best tactic is. This currently requires a lot of other boats to practice against and lots of real-world data to analyse (like trackers on every boat). It is impossible to know what the best tactic was with only the fastest boat being the best reference.

Given Sailing is a small sport, large gatherings of competitive boats usually only occur at events, giving little opportunity to put theory into practice outside of the real thing. This makes the only way to get better to go to training and events to learn theory and put it into practice, slowly working your way up the fleet, which is costly and time consuming, and irritating when you aren't doing very well. This makes improving hard and inaccessible to many sailors, especially those without connections for example coming from a non-sailing family background, at clubs with fewer resources for training, less experienced coaches and without parents willing to commit time or money to sailing. Making a computer program to teach and practice tactics will be a valuable teaching tool, practice resource and lower the bar of entry to learning how to win a race, which ultimately makes sailing more competitive and interesting for all involved.

Advantages

- Lowers bar of improving sailing
    - Decreases cost
    - Decreases time commitment
    - Lowers bar of entry

Disadvantages

- Adds complexity to download and set up the program
- Requires learning how the software works

- Increases opportunities to practice tactics
    - No need to large fleet
    - No need for big data as data can be created by the program
- Using a keyboard and mouse will not train muscle memory you learn in a boat
- Showing wind and tide conditions on a screen will be challenging to represent and interpret in a way that translates to experiences on the water

While there are disadvantages, I can take steps to make the system as intuitive, compatible, and easy to learn as possible with a tutorial and feedback from stakeholders. The tool isn't necessary to learn to race but a program to aid learning, and won't be for everyone, however, I can strive to make it accessible as possible for those who wish to use it.

To be a useful tool the fundamental feature would be to simulate sailing upwind. I would need to generate, or create a map and wind to sail on, perhaps procedural generation to get (near) infinite maps or custom maps that could represent real-world locations with the only downside being limited numbers of maps. I would use abstraction to calculate the speed of the boat using the sail's angle to the wind, wind speed and current speed (e.g., tide). The program would also need a way to choose where the boat goes.

Further features that would make it more powerful would be to calculate the fastest path upwind to compare to and the user could be given a score relating to their time round the course and the optimum time. To able to store the routes that are taken to compare with your own attempts and share scores and routes across users to see other sailors approach the same problems. A tutorial would be useful to introduce users to the controls and graphic design of the program, as well as introducing strategies for the sailor to use on the program and on the water.

Survey

Why the problem can be solved by Computational Methods

Thinking Abstractly

This is the primary aspect of my project as I must abstract many aspects of the program. Abstraction is all about separating ideas from reality, and that is exactly what this project is about.

For example, I must use problem abstraction to break down how to simulate sailing at all, using angle to the wind, wind speed, and current speed and direction, using calculations and vectors to approximate how these will affect the boat's movement. I will need to choose what control to offer to be done manually, e.g., adjusting the sail and what controls to automatically adjust/ignore for the sake of simplicity or focus. Communicating with stake holders to help choose what should be included and what key binds/mouse controls should be used for each.

These estimations are much better done on a computer than drawing on a whiteboard or using model boats to explain tactics as the user cannot actively partake in the exercise, and a computer can do much more accurate calculations than a whiteboard drawing, in much shorter time.

Additionally, I will need to use abstraction to represent the course. A simplified map of the area will be needed with a focus on where there is wind, where the wind is coming from and where tide is going. I will also need to think about how I represent information to the user, given it cannot be 1:1 with real life (I cannot have a compass on the bow which will be too small to see), but needs to be intuitive with parallels to their real life counterparts, or what sailors are used to, so the game does not have a massive learning curve. I need to use abstraction in a constructive way, so the game is designed for sailors.

Thinking Concurrently

The program will be able to handle multiple boats at the same time, doing the task of simulating the user's boat and NPC boats, giving the user competition in real-time, which is only otherwise possible, with lots of other boats on the water, which requires a level of organisation which usually only happens at events. This will be a huge benefit as it will allow practice with other boats outside of competitions.

Research into existing solutions

As per my survey, only 10.4% of sailors (11 sailors) use simulators/games to practice tactics, therefore, I will research existing solutions before asking my stakeholders about which features they would like to see implemented in my program, due to many of them not being aware of many current solutions. This will allow me to propose ideas from existing solutions for them to comment on.

Virtual Regatta - Inshore

Overview

This is by far the most popular sailing game, and I think it's representation of sailing conditions is the best. It involves features like a windsock next to your boat showing the current wind angle, which goes green when you have the best VMG (Velocity Made Good towards the mark). Gusts are shown in darker colours and lulls in lighter blue on the 3D and 2D course. Information is given to you about your boat speed, speed towards the mark, wind direction and wind speed in your current location. Virtual regatta uses a hybrid system of controls, with left and right controlled by arrow keys, and a tacking/gybing button (key bind: T). While you cannot trim the sail (let it in and out manually), you can press space to let out the sail and slow down. Virtual regatta does have many power-ups

which give the player (through a VIP subscription or lots of playing) an advantage, for example showing where the wind is going to come from (forecast), automatically setting the course for best VMG, showing wind shadows, lay lines, time on distance and telling you when you are in the right or wrong according to the rules before you collide with another boat. This makes the game less fair for those unwilling to spend time or money as the game tries to make money through a freemium plan on a game based on sailing rather than teach users how to sail better in real life. There are also simple tutorials to teach new users the basics of playing the game using real world sailing rules and principles.

Parts I can apply to my own solution

Features I may include:

- Darker and lighter water for gusts and lulls
    - This is the most intuitive way to represent wind for sailors, given this is what they look for on the water.
- Local wind direction
    - Telling the user what the wind direction is at their position is something we have access to on the water via a burgee/wind indicator. Depending on stakeholder's opinions I may or may not show the wind speed and boat speed as well (which we don't get on the water)
- Simple 'Tack/Gybe' control
    - Depending on stakeholder feedback this simple tack/gybe control with Auto VMG allows the user to focus solely on upwind or downwind tactics, which may be a useful option for my tactics simulator.
- Custom races
    - Virtual regatta has an option for custom races which allow users to change options for a custom race with bots or other sailors. While I may implement multiplayer, having the option to teak the race, course and options would be useful for power users and coaches.

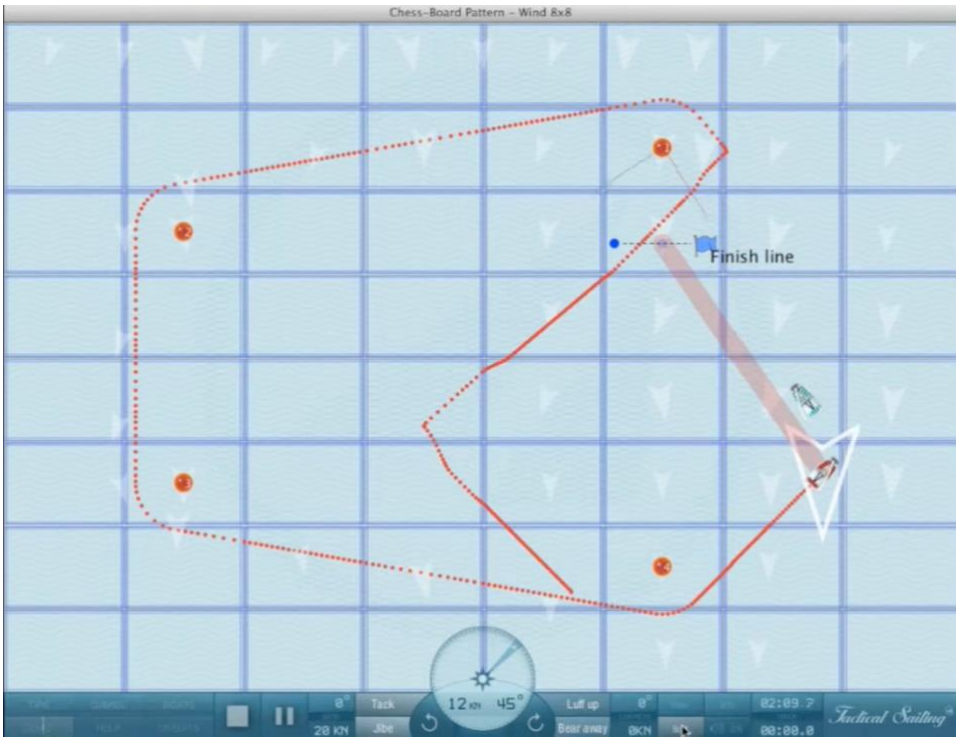
Features I won't include:

- Pay to win
    - I want this game to help sailors practice tactics, not make money, so I will only include realistic features and not lock unrealistic or overpowered 'power-ups' behind a paywall
- Online multiplayer

- Online multiplayer was not a priority for sailors and coaches who answered my survey, as this game focuses on your tactics to race together in real life, racing together virtually is not essential.

Tactical Sailing

Overview



This game most like my idea. While starting as a KISS (Keep It Stupid Simple) project it has grown to have many features; being developed for over 10 years. Its primary features are boat against boat where the goal is to beat the other player(s)/bot(s) and boat against wind, where the goal is to finish in the best time. The program has many tutorials and scenario modes where you can learn tactical principles, the racing rules of sailing and practice upwind, downwind, reaches, VMG (Velocity made good), starts and full races. You

can use different class boats, multiple players or bots and control the boat in a few different ways.

Above is the control bar. On the left there are setup options, like what game you are playing, boat class, tips and where other fine game adjustments can be made like how many boats there are and what the course is. There is a stop and pause/play button next to information on the wind direction and speed. How the boat moves are controlled by the

next buttons: Tack/Jibe automatically turn the boat to the other side of the wind, Left/Right turn left and right while Luff up and Bear away turn towards and away from the wind respectively. Finally, you the compass, which displayed the sailing direction and speed can be clicked and held. By moving the mouse left and right the boat steers left and right, giving analogue control. Lastly, when hovering over the compass, the scroll wheel can be used to steer. The next box displays information on current speed and direction which factor into boat speed. The last boxes control view settings, the tutorial/info box, and the narrated sound (which reads out what is in the Info box). Finally, there's a timer for how long has been spent on the current scenario.

Parts I can apply to my own solution

Features I may include:

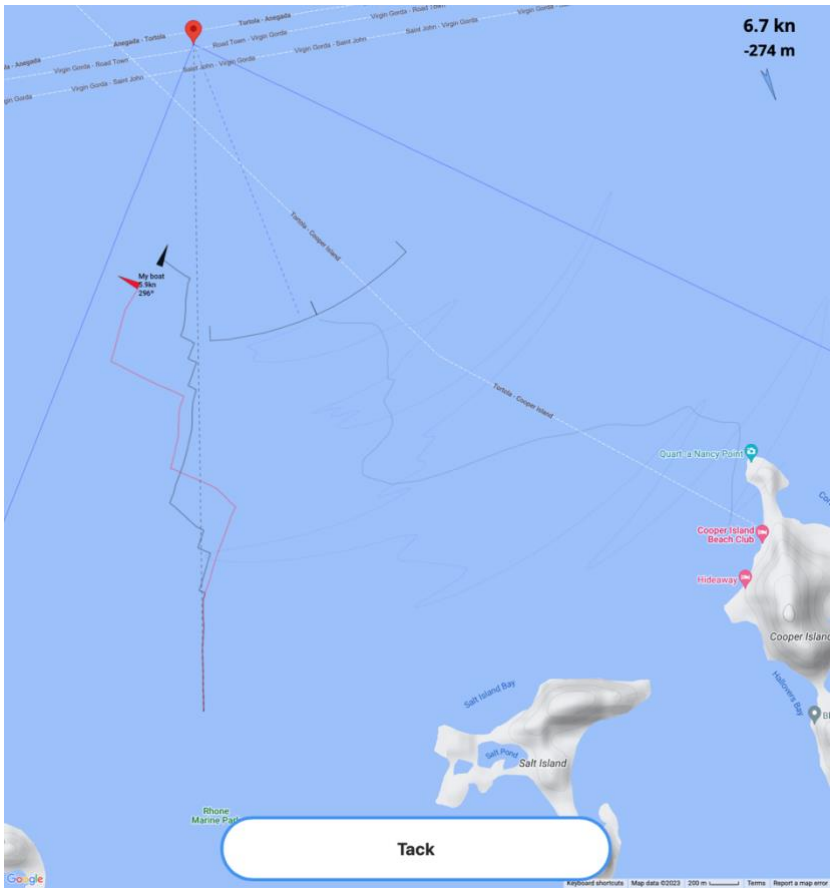
- All points of sail
    - I think practicing tactics throughout all points of sail would be most useful, allowing the user to sail a complete racecourse in the simulation.
- Varying wind
    - The wind angle and strength change in up to 64 different squares in this game, with closer representation to real life where wind speed varies with gusts (higher wind speed) and lulls (lower wind speed).
- Scenarios/Tutorials
    - This game has many tutorials, and if I can, I think teaching basic skills and tactical principles, or creating scenarios that coaches can use to explain these, would increase the game's usefulness, especially to novice racers.
- Course trace line
    - I like how the tracer is represented by dots, where they become sparser when going at higher speed and closer together at lower speed, indicating speed intuitively.
- Starts
    - While starts require many manoeuvres that cannot be practiced virtually (on a screen), due to needing to learn muscle memory, there are tactics behind choosing an end of the line to start at and navigating around other boats which could be beneficial. Tom, an international sailor who did my survey asked for: "Starts and course bias".

Features I won't include:

- Wind arrows

    - With stakeholder feedback, I don't think the arrows are the best way to represent where wind is. When sailing it is very hard to know what wind direction it is in different locations, so I believe that should be hidden from the user until they are in that location. Additionally larger arrows are not very intuative (there are no big arrows on the water when sailing) but there are darker and lighter patches of water (due to ripples).
- Different boat classes
    - Different classes will go at different speeds relative to the wind. Jemma, a club sailor who did my survey said: 'For me the tactics and technique must be specific to my type of boat' and while I agree about technique I believe if other boats are the same class, tactics will be transferable across classes, unlike technique.

SailRacer's Wind Game



Overview

This game is all about taking advantage of wind shifts and tacking at the correct time, so you (in red) beat the boat (in black) which follows' SailRacer's tactics app, which is SailRacer's headline product.

The game is set in a real-life location using google maps data while wind data is real-time from a local weather station. The only control is tacking, where a 10% speed penalty is applied for 1 second, and the boats automatically sail close-hauled (as close to the wind as possible - you cannot sail straight into the wind). There are no racing rules applied, keeping the focus on the wind, and tacking, however, there are several visualisations giving you information. Wind speed is in the top right corner with the distance to the SailRacer boat and wind direction. Next to your boat is your speed and compass pointing. The blue dotted line is the wind direction while the solid blue lines are

the lay lines (line on which you can sail straight to the dropped pin at that wind direction). A light blue line shows the historic wind direction while a black line shows historic average wind direction. The black arc section shows the range of the recent wind shifts and recent average wind direction. Lastly the black and red lines show the course taken by the respective boats.

Parts I can apply to my own solution

Features I may include:

- Simplified 'Tack' control
    - Enables user to focus on upwind tactics. I will ask my stakeholders about their preferred control methods or perhaps have multiple control methods which users can choose based on preference or what they are focusing on. Other control methods may be needed for other parts of the course (e.g., downwind).
- Course trace line
    - This allows you to see where you have gone or where other boats on the course have tacked, aiding informing tactical decisions.
- Compass Bearing
    - Many sailors have a compass on their boats, providing this very useful metric, especially on a virtual sailing simulator, it is much harder to keep track of where you are pointing (whereas you can use a landmark, what we call a transit, in real life. E.g., a mark, hill, or tree).
- AI boats
    - To compare how well the user is doing, I want to implement at least one other boat which shows an alternative route, or/and the fastest route around the course. Tom Hakes, an international sailor who did my survey said: 'Would be awesome if the computer could calculate the fastest route […] to the mark and compare it against your own".
- Wind statistics
    - The user will need to know where the wind is coming from and how it changes across the course. I will need to show what the wind speed and direction is in their current location, however in my program the wind may not be the same strength and direction across the course so will need a different way of representing wind strength and direction in different locations.
- Real world locations

- Depending on stakeholder feedback, I think using real locations, with representative wind and current conditions for that club would have the potential to be most helpful, however would be less useful to users in other locations, where a generic or customisable map would cover more situations.

Features I won't include:

- Real time wind
    - I want to let sailors practice whatever the actual wind conditions are (e.g., no racing due to no wind at an event but you still want to practice), so custom or generated wind may be more useful
- Focus on just tacking
    - Depending on stakeholder feedback, practicing tactics will require more than just tacking, e.g., starting may require you to stop completely, or you may want to duck (go behind) a boat instead of tack in a Port/Starboard rule situation.

Stakeholders

The target audience are sailors who race and want to learn and improve their strategy. People who compete at different levels (club, national, international) across different classes (ILCA, Optimist, 49er, NACRA 15 etc.) will be essential for making the tool useful for different competency levels and across boat designs. Feedback from Instructors would also help to make the tool useful for teaching as well and making adaptations for a classroom setting.

Harry McTeirnan

Harry is an 18-year-old who has grown up with years of experience sailing in many classes including the ILCA 4/6, RS Terra, RS Feva, Fireball, Mirror, RS 200, Spitfire, F18 and Dart 18. He sails at his club events but also takes part in Regional, National and some International events. He's doesn't sail as much anymore but coaches with his Dingy Instructor and Race Coach Lv. 2 qualifications from RYA, which he has done for the last 3-5 years.

Which control methods do you prefer?
Harry wanted arrow keys/WD for turning left and right and the ability to manually adjust the sail, which many simulators don't offer. Stating "it's simple and I'm dumb".

What information should be given to the user?

Harry wanted to see wind direction and speed across the course and locally with boat speed in a “HUD in one of the corners”, a bit like Virtual Regatta. He suggested currents across the course to be presented as “Arrows or moving lines [streaks] in the channel”.

Should there be custom maps?
Harry thought there should be custom maps, which are “not super important if the course is good but would be fun. […] Not an exact replica, but the key aspects/humorous rip-off”.

Should there be Tutorials?
Harry thought there should be Tutorials that are “not forced” and “short and simple”. He suggested topics like “Racing Rules, Boat speed and starts” but didn’t think the game needed to teach tactical principles.

Should there be multiple boat classes?
Harry wanted multiple classes of boat to practice in.

Should there be other boats on the course?
Harry said there should be “NPC boats [with] mixed levels, but not too powerful. Maybe one that always does bad for a meme?”. He also thought it would be useful to have a mode with only NPC boats, which could be useful for instructors.

Any other feedback/ideas?
Harry wanted the game to have some fun and character, suggesting “a slideshow at the start which introduces Race Officer, the boats, and the course? Some cartoon […] race officer changes each time and explains the event and tells you if you break a rule. Plus, some funny generated names and sail numbers for the other boats. (Nat Rusty, Joey Hemmerson, Sarah Escargot etc.)”

Monty Desforges

Monty is an international sailor who’s sailed some traditional classes including the Optimist and ILCA 4/6 while also having sailed the RS Feva competitively. He uses a simulator/game to practice currently, called Virtual Regatta - Inshore. He sails primarily at

a National and International level. He's also been an Assistant Instructor for the last 1-2 years.

Which control methods do you prefer?
"Basically, I'm just a virtual regatta nerd- I'd say copy virtual regatta, we all use it, it will lower the knowledge barrier for entry, (but please use WASD VR [Virtual Regatta - Inshore] uses QDES […]). Scroll wheels/dragging [to steer] just sounds a bit fiddly for me and could be used for other things. [...] like in VR, auto VMG and a tacking button should be something the player can toggle and choose to use, not be forced to. This (in the case of VMG) allows people who are new to the game to not have to think about their angle, but experienced players can play around with modes and velocity looping by making tiny heading changes. This also supports arrow keys or WASD."

What information should be given to the user?
Monty thought that Wind speed and direction should be given across the course using arrows/windsocks to show direction and lighter and darker water so show wind speed. While he'd prefer using arrows, he sees "the argument for using a compass bearing, as it's how the info would be presented to us on a boat". He also thinks compass pointing and boat speed should be presented, perhaps in a HUD. He realises "I'm still just emulating VR [Virtual Regatta - Inshore]!!! It's what I'm used to" but thinks the program should "Implement as much as possible here and let the player decide, there's a good case to be made for either one [compass bearings or arrows], both have different use cases and doubtless everyone will have different preferences."

Should there be custom maps?
"I think since sailing is so location specific, having some generic location presents (e.g., generic coast venue, generic lake venue, generic tidal estuary) is important, as this could influence the wind and tide. [In my opinion], modelling actual venues (e.g., WPSNA, Grafham, Lymington to give the counterparts to the above) is a nice gimmick if it was purely cosmetic, but because you couldn't accurately model the intricacies of the venues *in the time you have* (although this would actually be a game changer for the sport if it ever existed) isn't a priority."

Should there be Tutorials?

“I just think [Tactical Principles and the Racing Rules of Sailing] might be the two [ideas] people are least likely to properly understand, the [boat speed and starts] people will pick up (that’s kind of the point). No-one actually understands the RRS [Racing Rules of Sailing] but everyone pretends to, so setting out some basics might be useful, plus basic tactical plays.”

Should there be multiple boat classes?
“Again, I don’t think this is a priority- I can see it’s a nice detail but might be a bit of a challenge to model. It’s the sort of thing you add after you’ve got a working sim.”

Should there be other boats on the course?
“Ultimately, racing is trying to beat the fleet, so we need a fleet to beat!! If I knew there was a boat following the fastest course, I’d just cover it- I think that defeats the purpose of trying to figure out the fastest course (although an accuracy rating of ‘how close you are to a fasted course’ could be an idea). Real time multiplayer would be amazing, but I can imagine this is a royal pain to implement racing against AI’s would be great as an offline mode, or just practicing at 3AM when no one else is online. To me, [A boat following the fastest route and NPC boats only] seem a bit useless.” However, Monty thought “A mode where you can get boats to play out a pre-planned course [would be] useful for instructors, and perhaps juries?!”

Any other feedback/ideas?
“This is a bit wild, but I feel like it would be amazing if you could: (A) take tracking data from a race, upload it to this simulator and look at it, then play against either bots from a certain position you had in a race, or against what already happened. Imagine that as a post-race aid!! (B) by implication, watch and play through famous races that have available tracking data (e.g., SailGP, AC, sailing World Cup or Olympics)”

Sara Goujon

Sara is newer to sailing, currently working her way up the fleet an ILCA 4, competitively at a National Level. She has also taught sailing for the last 1-2 years as an Assistant Instructor.

Which control methods do you prefer?
“I think arrow keys could be good because it can be sensitive but doesn't limit you for other functionality (you may have to use the WASD keys). The mouse would be quite helpful to use to look around the course. I think sheeting with the scroll wheel would work because it's really quiet like a ratchet block and that means that we could easily make small adjustments just like we do when sailing. Auto VMG could be really useful if used as a beginner mode for newer sailors if they are trying to focus on other skills.”

What information should be given to the user?
“I think that these should [toggleable] depending on what you are trying to train for. If the user has the ability to switch on the various [features] you could for example view the wind across the course. This could help the user understand how is bends and changes over a course. Then turn it off and start to predict how it would change with land features etc. They could then review how the wind changed at the end and look back to see if there would have been a more efficient way to sail the course. I feel like that would be the most effective way to use it without worrying if you are giving to much or not enough information as you go through development.” She had this to say about currents/tide: “You could show how the true wind and then the apparent wind that has been changed by the tide with different windsocks. When we are sailing normally there is no real indication on the water [of the tide] unless you are at a mark so you could show the users tide maps beforehand. Or use white marks to the side of the boat and across the course.”

Should there be custom maps?
“I think that being able to model it around known venues will allow us to train better for an event, but it could also use imaginary locations with specific features that demonstrate specific skills or tactical advantages. I think having land features is quite crucial.” She thought some locations needed would be “Weymouth, Hayling Island [and] Grafham water”

Should there be Tutorials?
“I think there should be tutorials because it will help sailors learn faster and get the most out of the program. I also think that machine calculated routes and 'debriefs' would be a very useful tool to help understand a race and the conditions while evaluating your performance. Overall, I think the program would still be very useful without, but the tutorials could really enhance the simulator.”

Should there be multiple boat classes?
“Yes, there are huge tactical differences depending on the boats you sail from start technique to sailing with or without spinnakers.”

Should there be other boats on the course?
Sara thought there should be Real time multiplayer, NPC boats to race against, an NPC boat following the optimum course and a mode with only AI boats all as options: “When training you will not be successful by using only one method or trying one technique so having multiple options or modes can allow different focuses and you to learn a variety of skills. Real time multiplayer is in my opinion crucial because it will bring a competitive and enjoyable element.”

Any other feedback/ideas?
“If it's possible, adding waves would be really useful. A variety of venues (offshore and inland) so that localised gusts with lifts and headers alongside tide and waves can be practised. Different colour boats. Emoji reactions for real-time multiplayer. Kites for double handers. Modes for lay lines and start lines marked on and modes without. [A top-down view] across the course but also [an] up-close on the boat to change sail position and controls.”

Josie Kelly

Josie is a long time National Level sailor, who’s practiced in the RS Tera, RS Aero and most recently the ILCA 4. She also teaches others sailing as a Dinghy Instructor, which she has done for 3-5 years.

Which control methods do you prefer?
Josie wanted a 1-button tack/gybe but also wanted arrow keys to turn the rudder and manual sail adjustment: “I Think that using 1 button to tack/gybe allows ease for play but tactically would want to steer and control sails separately to allow for learning the ideals.”

What information should be given to the user?

Josie wanted to see wind direction and speed across the course as darker and lighter water she also suggested showing the speed value of the wind in knots across the course "to allow a clearer idea of where the wind is and how strong it is where". She wanted to see boat speed and tide using a HUD and "arrow[s] with labels to allow to see tide differences. Although this is unrealistic it can help tactically to show the differences with using tide."

Should there be custom maps?
"I think [the user] could have both [realistic maps and generic/custom maps] depending on what you're trying to teach/practice. E.g., Could create a place with a load of tide if you would want to practice/teach tide. Realistic is also good as helps train for events. Would like WPNSA, HISC, Rutland, Draycote [and] internationals too"

Should there be Tutorials?
Josie thought tutorials should be on tactics, RRS, boat speed and starts but "Should only be at the beginning/used for basic Knowledge and then anything after that is self-taught or applied from real racing "

Should there be multiple boat classes?
"Yes, gives variation of sail adjustments and how to apply knowledge to different types of boats - more realistic to real life "

Should there be other boats on the course?
Josie said, "Multiplayer allows [different players] to go different routes […] and then discuss what work[ed] and why afterwards." She also liked an NPC boat only mode: "Good [idea] to see the […] route[s] by AI"

Any other feedback/ideas?
Josie thought about tutorials for starting and races saying the program "Could use flags to help teach starting sequences. Can choose different starting countdowns depending on what's being practiced." She also wanted custom modes/tutorials, for example "not a race and just practices with courses so could do many up winds if necessary".

Summary

All the stakeholders prioritised controls that they were used to and were intuitive from playing games. However, they wanted this simulation to go further than other games and allow control over sail settings, especially the main sheet. I particularly like the use of the scroll wheel as the main sheet as it's very similar to a rachet block we use on real boats. They thought that there should be different options depending on what you are focusing on, like auto tacking/auto VMG, but they should be toggleable like in Virtual Regatta - Inshore.

All my stakeholders had varying opinions on what should be shown to the user, but Monty thought most of the options should be implemented and customisable by the user. Sara agreed with this, saying that you could change what's on the HUD depending on what you want to practice. They all agreed that wind should be shown across the course, primarily as lighter and darker patches, alongside current information, which many suggested should be done with streaks/arrows alongside an arrow by the boat showing the local tide impact.

Most stakeholders thought there should be a range of locations. Monty thought there should be some generic locations to generally cover all bases as a priority, however all agreed having accurate real-world locations would be game changing wanting a mixture of inland and offshore venues, primarily regional and national UK venues alongside some international venues.

All stakeholders agreed there should be some form of tutorials covering the basics of the game and sailing, however, they should be optional and, apart from teaching controls, aren't a priority but would greatly improve the game for newer sailors.

All stake holders thought there should be the option for different classes, but all agreed it wasn't a priority for tactics, but the main features of different boats would be the first to be wanted included, e.g., spinnakers, jibs, foiling boats, and controls.

All stakeholders wanted real-time multiplayer, but Monty thought compromising for NPC boats would be acceptable, given they can be played online or when no one else is playing. Many thought that having an NPC following the fastest route would be useful to

compare post exercise but not during as you will aim to follow/cover them, taking away the point of the game. The NPCs should generally be balanced.

The stakeholders all had many extra ideas, from briefings with make-up race officers, to importing tracking data, waves and start sequence flags, all of which they said would be great to see but a working simulator is their priority.

Features of the Proposed Solution

Below are all the essential features for the solution:

Feature	Justification	Possible improvements
Simulating sailing upwind	Most gains and losses in a race are made upwind so the essential feature is that the game can simulate sailing upwind	Simulating sailing at all points of sail so a whole race can be sailed.
Simulating Shifts/Wind Bends	Lifts and Headers (where the wind shifts so you can point higher or lower) are one of the main aspects of making tactical decisions and are required to make the game useful for learning tactics.	Relating Shifts to gusts and lulls, shifts almost always happen with a gust or lull.
Simulating Gusts/Lulls	Gusts and lulls bring lifts and headers and are also areas of higher or lower wind, making them essential to tactical thinking. More wind = More speed so is a primary factor in how you sail up the course.	
Simulating Currents/Tide	At coastal/estuary locations, the channel is either an advantage, pushing you	Simulating tide with varying speeds and directions

	towards the upwind mark, or a disadvantage, slowing you down. Simulating its effect basically with a constant direction and speed is essential to learning tactics for tidal locations, and a challenge for inland sailors.	
NPC boats	Sailing races are all about beating other boats, so additional boats should be included to compare yourself to, and think about tactically, for example, how to mauver around other boats in rule situations, or avoiding dirty air (an area of less wind behind another boat)	Multiplayer allowing two sailors to play against each other locally or online.

Software and hardware requirements

While the most popular device sailors use is a version of iOS (>70%), I will first develop the program for Windows, Mac or Linux using python which will still reach over 70% of sailors and instructors.

Hardware

- Computer compatible with python (x86/Apple Silicone)
- Display/Monitor
- Keyboard
- Mouse

Software

- MacOS, Windows or Linux
- If I don't package the program as an exe/dmg you will need:
    - Python
    - PyGame

Success Criteria

- The game must have a top down 2D representation of a course
- User must be able to sail a boat upwind
    - User must be able to identify their boat
    - User must be able to sail on a close-hauled course
    - User must be able to tack
- The map/course must have varying wind speed/direction
    - User must be able to identify gusts and lulls
    - Boat must change speed depending on wind speed
    - Boat must change direction/speed depending the sail (or boat's) on angle to the wind
- The map/course must have varying and logical current speed/direction
    - User must be able to identify channels and tide strength and direction
    - Boat must change speed and direction depending on current speed and direction
- NPC boats must be on the course
    - User must be able to identify other boats on the course
    - NPCs must be competitive but balanced, with some behind and some ahead of the user (if they can beat the user)

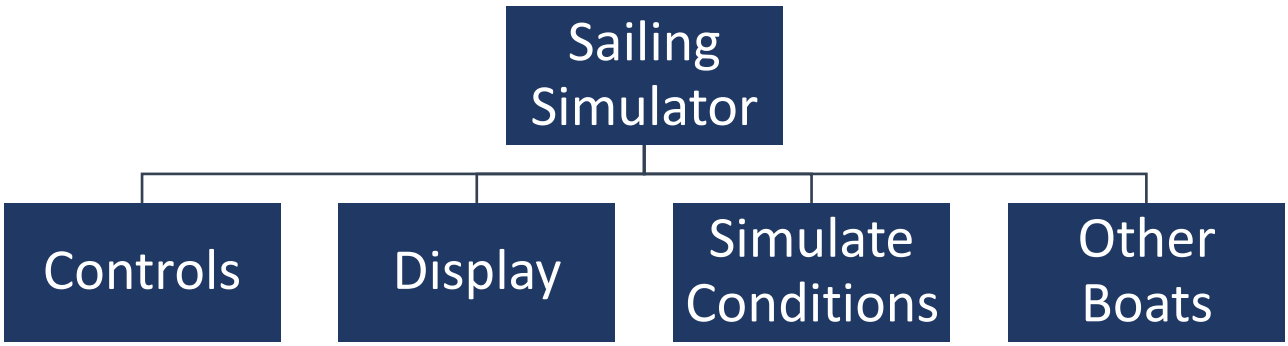
- NPCs must follow the same boat speed logic as the user's dingy

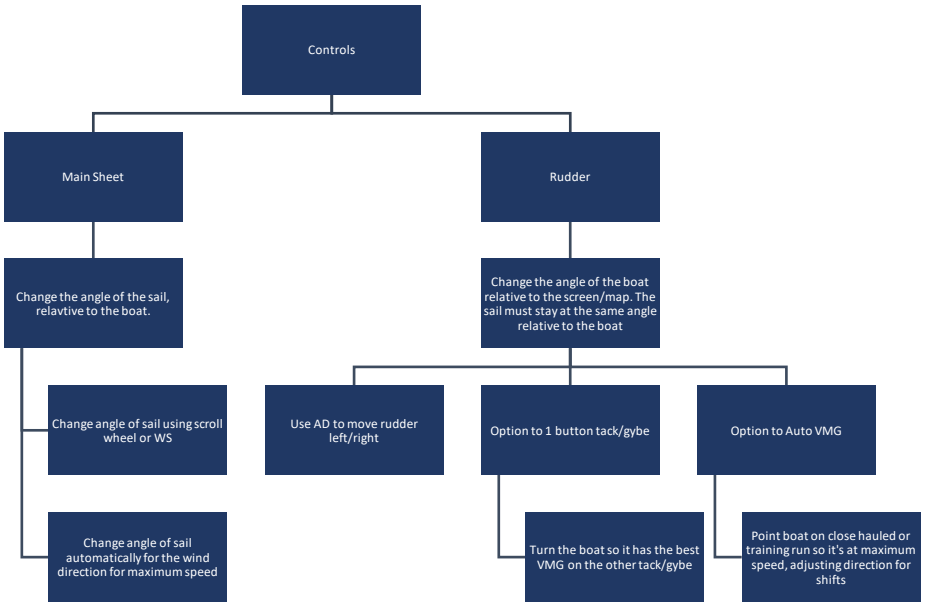
I will document meeting each requirement though videos and testing by stakeholders.

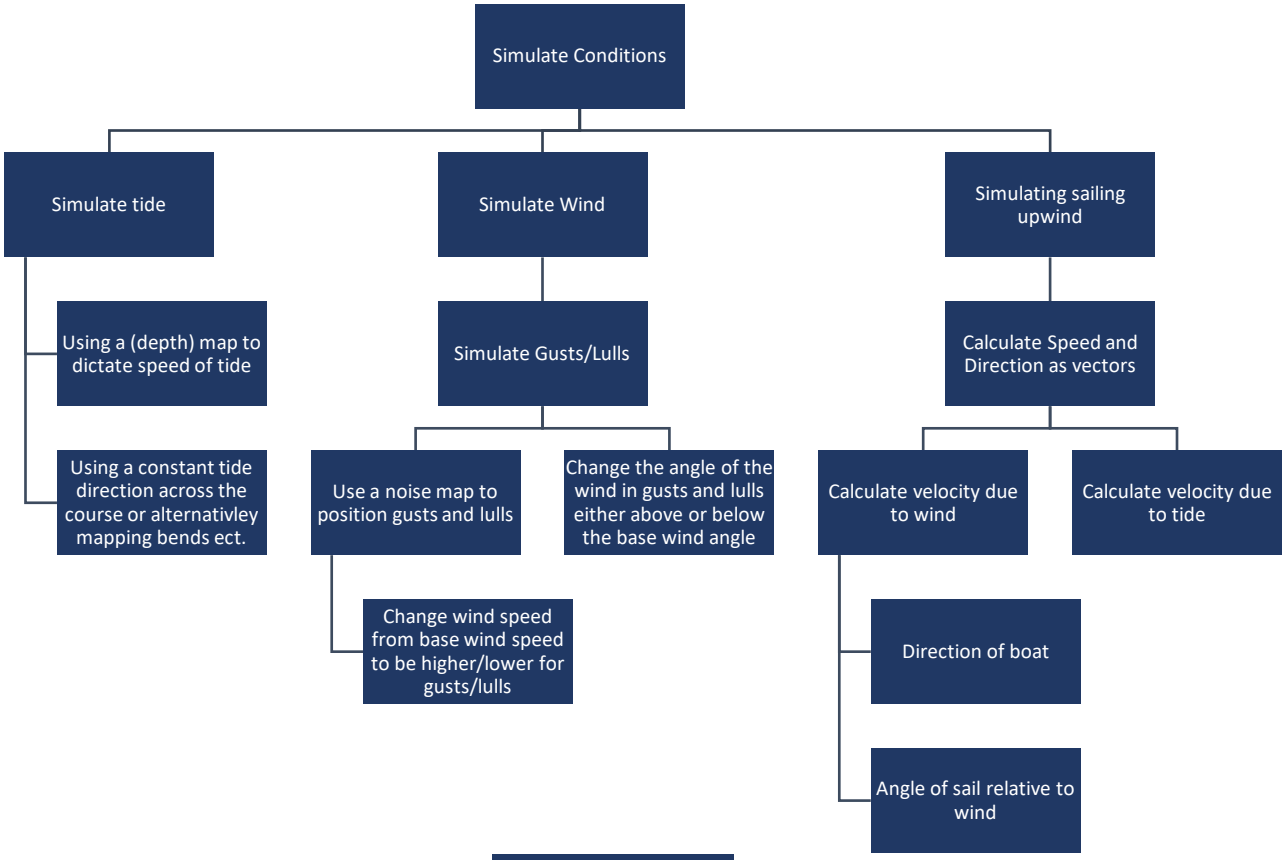
Design

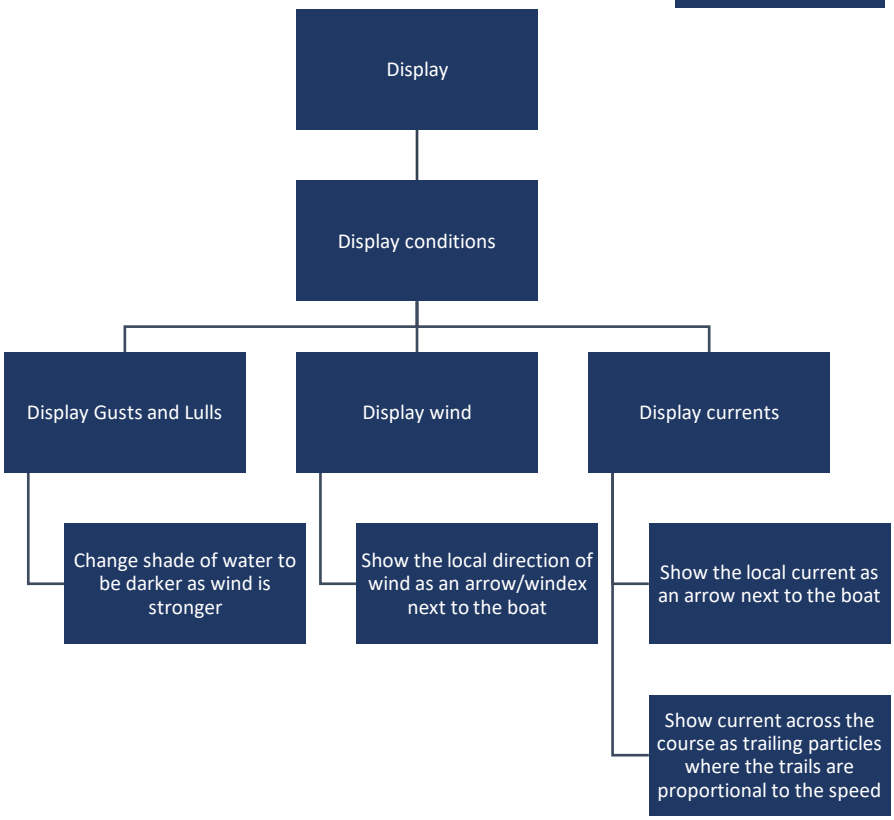
Decomposing the Problem

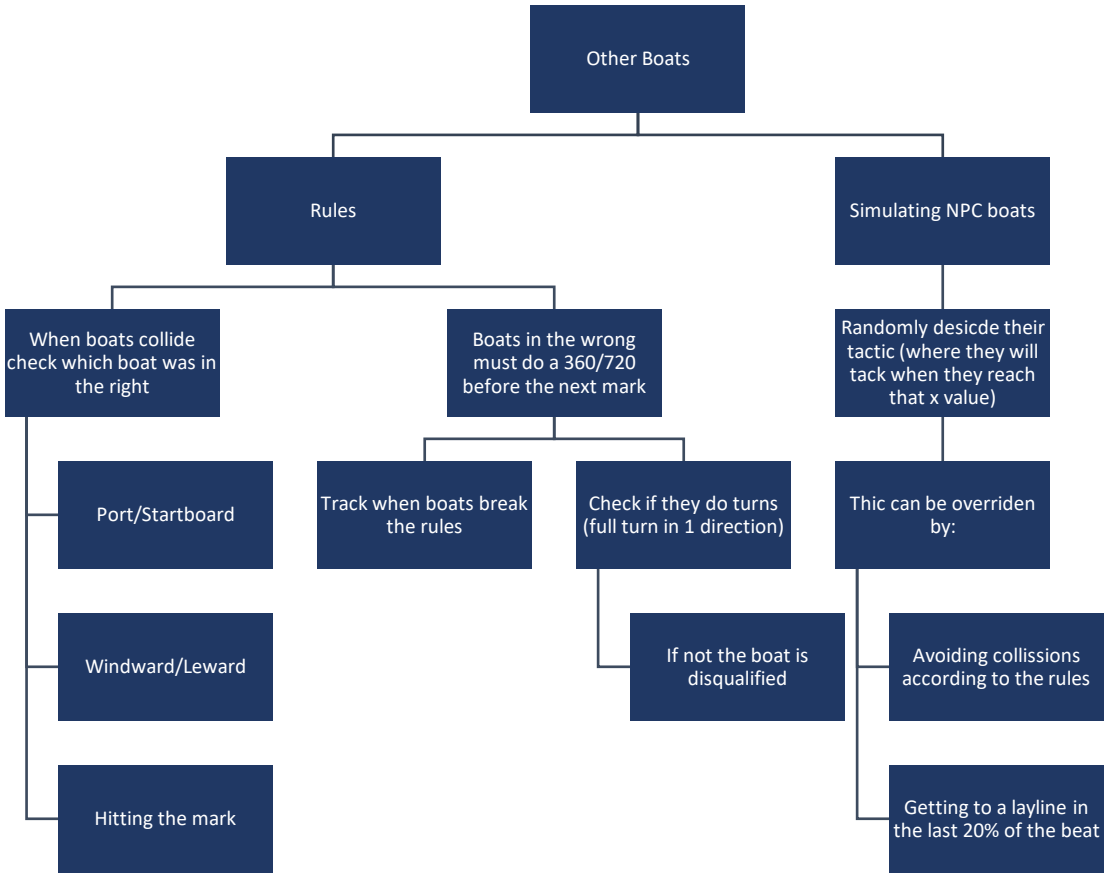
I've broken the features of the program into 4 main components and detailed each one into how to solve each problem. I chose these 4 categories as they each cover related subroutines with little crossover (Apart from display, which crosses over with all of them).






Simulate Conditions
Simulate tide
Simulate Wind
Simulating sailing upwind
Using a (depth) map to dictate speed of tide
Using a constant tide direction across the course or alternativley mapping bends ect.
Simulate Gusts/Lulls
Use a noise map to position gusts and lulls
Change the angle of the wind in gusts and lulls either above or below the base wind angle
Change wind speed from base wind speed to be higher/lower for gusts/lulls
Calculate Speed and Direction as vectors
Calculate velocity due to wind
Calculate velocity due to tide
Direction of boat
Angle of sail relative to wind


Display
Display conditions
Display Gusts and Lulls
Display wind
Display currents
Change shade of water to be darker as wind is stronger
Show the local direction of wind as an arrow/windex next to the boat
Show the local current as an arrow next to the boat
Show current across the course as trailing particles where the trails are proportional to the speed



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