Easy Rider

Easy Rider Navigation System: In the Pursuit of Riding

Part 2 - Design Alternatives

Team members:
Urs Bischoff
Jaemin Lee
Hemanshu Narsana
Victor Bigio
Matt Wolff

Table of Contents

Project Description

In a typical "group" ride, members of the Southern Bicycle League, our users, get together with a volunteer ride leader to go touring. At the start of the ride, the ride leader distributes a map and/or a cue sheet to each of the riders. The information provided by the current "navigation system" is limited to the routes and stops (for water and/or food) designated by the ride leader. While riding the rider must repeatedly review the route information to decide where to turn, and where to stop. The purpose of the proposed "navigation system" is to dynamically provide route and resource information to a rider that will aid him/her to ride through unknown territory, with a minimum of distraction and a high degree of flexibility. The system will actively inform the rider when he/she is approaching a turn or a stop, allow the rider to change the route, or create a new one at will, and provide extensive resource location information. Additionally, the system will be able to record the actual route that a rider takes for later analysis.

Requirements Summary

Functional Requirements

- Follow the route: Inform the rider when and where to turn, and when a planned stop is near.
- Change/create a route: Allow user to dynamically change the current route, or to create a new route.
- Locate points of interest: Provide a search capability so the rider can locate necessary resources such as food, water, a bike shop, medical aid, and campgrounds.
- Record route: Record the route the rider is riding, storing waypoints, distances, and times.
- Provide present location: Provide the rider with his/her present location, as well as the distance to waypoints and/or to stops along the route.
- Download /upload routes: Connect with mapping system to 1) download current maps, 2) download preplanned routes 3) upload recorded routes
- Work in limited capability mode: Even if the route tracking capability is down, the system should still provide basic map and route information, at least as much as the original map and cue sheet provided.

Non-Functional Requirements

- Provide consistent response: the rider needs to have confidence in the device, and know what to expect regarding response times.
- Adjust to ambient conditions: Automatically adjust to light and/or noise conditions.
- Sturdy: the device will need to withstand vibration and some shocks
- Lightweight: should not add significantly to the weight being carried on the bicycle.
- Mobile: this is a given, the question is where to mount the device
- Easy to setup: the device on its own should require minimum setup, and once a route is downloaded, should allow route tracking with no further setup. There is another component (see Mapping and Navigation below), a "black box" that will also require setting up and connection to the Internet.
- Easy to use: the critical function of route tracking should require little or no training. Additional functions, such as route modification, may require additional training.
- Maximize recoverability: even if the user commits an error, the device should always allow the rider to return to route tracking, and load the original route
- Waterproof, rustproof: the device will be used outside, and needs to be able to withstand the elements

Mapping and Navigation

When we started exploring the design space, even before we talked about possible designs, we talked about the mapping, routing, resources and navigation information and technologies that need to be part of our overall system.

Navigation

The prevalent navigation technology today is GPS, or Global Positioning System. Each of our designs will incorporate GPS technology to implement the tracking function. Please see Appendix A for a description of GPS.

Mapping, Routes and Resources

Each of our designs will have the ability to connect to another system in order to download current map and pre-planned route information, as well as the ability to upload a recorded route and waypoints. Since this technology is already well developed and available, we decided to treat it as a "black box", and use it as part of each design. The Internet will be the primary source of up-to-date maps and the location of resources. Please see Appendix B for a summary of our "black box" functions.

Design Space

Our analysis of the problem space in Part One uncovered several limitations of the current navigation system that riders use while touring (i.e. the map and/or cue sheet provided by the ride leader). The main problems for the rider are 1) the distraction of having to refer to the map and/or cue sheet 2) the lack of flexibility regarding the route and 3) the limited information about places to stop for water, food or other necessary resources.

Since a "group" ride does not guarantee that the riders will stay in a group, our design space considers an individual rider touring on a bicycle. While following a pre-defined route, we want to enable the rider to focus on riding, so our system should inform the rider about turns and stops without rider intervention and a minimum of distractions. At the rider's request, the system should allow dynamic route change and creation, and also provide information about the location of resources. The system will also record the route for later upload and analysis.

In the following pages we attempt to describe the process we used. Although it seems that one step follows another, the process was actually quite iterative, with lots of back and forth.

Data Exchange

During brainstorming sessions we first looked at the kind of information the device and the users need to exchange, given the functional requirements.

<u>Device to user</u>

- Where to turn, where to stop
- Possible routes
- Distances
- Current location
- Possible destinations
- Show a map

<u>User to device</u>

- Explore area
- Create waypoint
- Change waypoint
- Show (i.e. tell me): distances, places to stop, waypoints, routes
- Select: waypoint, stop, route

Metaphors

Once we had a solid feeling for the types of information that needs to be exchanged, we decided to explore the different metaphors we thought our riders would be familiar with, since this will make learning and using the device easier. Here's what we came up with:

- Map: this is what most of them use now, with the ability to explore the map
- Buddy: a friend who knows the route, and can inform the rider, and the rider can talk to
- Signs: billboards, signs posted by the side of the road, overhead signs, arrows painted on the road. These are familiar to any person who has tried to navigate any road.
- Cue sheet: some riders currently use this list of turns and stops.
- Turn arrows: just like the blinking turn signal in the car
- Beeps: like we now experience when many devices want our attention (pc, auto, doorbell)

Critical Factors

Finally, we determined the critical factors that will influence our designs, and the acceptability of the device:

Parameter	Description	Range
Distraction	Amount of attention the user gives the device while riding	• Minimal • Low • Medium
Density of information	How much information can be provided at one time	• High • Limited while riding, high when stopped • Limited
Flexibility	Ability to flexibly change/create routes	• High • Limited while riding, high while stopped • Limited
Map Display	Does device display a map?	• High while riding • None while riding, high while stopped • None
Learnability	How easy is it to learn for a novice user	• Easy • Medium • High
Technology	How difficult is it to implement the technology for this design	• High – futuristic • Medium – short term • Low – existing technology

Before we actually came up with any designs, we looked further at the design space from a very basic interaction point of view, in order to explore the possible embodiments and modes for our designs. More detailed information can be found in Appendix C.

Difficult Requirements and Tradeoffs

In general none of our functional requirements are difficult to realize on their own. The real complexity arises when we considered implementing one device that could fulfill all of the requirements.

In discussing the different options available to us regarding input and output, we realized that the primary conflicts revolve around the granularity and density of information exchanged.

- If our device displays a map, the user is provided spatial orientation, and potentially a large amount of data. This needs to be balanced against the riders ability to concentrate on the road and the ride.

- Speech as output will provide very little distraction to the user, but the density of information is low, and detailed information will take a corresponding amount of time to convey.

- Speech used to control the device will also create less of a distraction than manual control, but just try to explore a map using voice commands.

- One of the most powerful metaphors we explored was the concept of road signs. A see though display would work well for this, but might provide a challenge if trying to control the device while riding, since the display is in the field of vision.

Designs Explored

After we listed the multitude of information and interaction our designs could incorporate, we started looking at possible designs. Here are the ones we came up with:

1. Electronic Paper: a flexible flat, foldable display and input device. Similar to a tablet pc, but the rider can fold it and put it in a pocket, and can control it by pressing on its surface.

2. Audio Input and Output: speech and non-sound output via an earpiece device attached to the helmet, speech input via a microphone, also attached to the helmet

3. Map display: a flat lcd-type display over the stem of the handlebars for output, manual controls (buttons, toggles, wheel, etc) mounted on the handlebars, and reachable while riding

4. Eye projector: direct eye projection mounted on the helmet, speech input via a microphone, also attached to the helmet

5. See through display with augmented reality: augmented reality glasses that will display an AR image superimposed on the real world, with cameras in the frame to detect hand motions

6. Hologram: a 3D display that shows an image in front of the rider and displays map information.

Important Characteristics of the Designs

Following are some of the key characteristics of our 3 designs:

	Design 1	**Design 2**	**Design 3**
Metaphor	Map	Buddy	Road signs
Distraction	Medium	Minimal	Low
Input	Buttons/Touchscreen	Speech	Hand motions
Output	Video display	Speech & non-speech audio	Augmented reality video
Technology Requirement	Low - existing technology	Medium - short term	High - futuristic
Flexibility (change/create routes)	High	Limited	Limited while riding, high otherwise
Learnability	Medium	High	High for following route, medium otherwise
Density of Information	High	Limited	Limited while riding, high otherwise

We chose the following three designs primarily because of the rich metaphors they provided to the users.

1. Maptacular
    - Uses a map metaphor
    - Provides spatial orientation
    - Allows fine control of map (panning, zooming)
    - Can present a wealth of options
    - Navigate through menus
    - Change/create route visually

2. Cycling Partner
    - Uses buddy metaphor – like friend riding with you
    - Minimum distraction, can listen and talk while riding
    - Requires least overall training
    - Requires least overall sophistication

3. Magic Glasses
    - Uses the signs metaphor (road signs, overhead signs, billboards, arrow on road)
    - Minimal distractions
    - Easy to use while following route
    - Extensive granularity and density when stopped

Designs

Design 1: Maptacular

Description

When riders participate in a ride, they receive a map and/or cue sheet from the ride leader. Many riders are familiar with the format of a map and are able to read maps while riding. Since the riders are familiar with maps, we could use technology to create enhanced maps which allow the rider to concentrate more on the ride and less on the map.

The interactive map is a video display unit that provides the user with route information in a visual format that is similar to paper maps. Riders can not only keep track of their current route, but create new routes, edit their current route, or search for points of interest along the route.

Riders activate the interactive map by selecting a route which has been stored in memory. Once the route has been selected, a map is displayed on the screen with the rider's current location, the next route waypoint, and points of interest. The device will also display the direction the rider should ride to reach that waypoint. As the rider continues riding, the device will record the progress of the rider for later review. If the rider decides to change the route, they can add or delete route waypoints at any time. Riders may also create new routes on the device in the create mode.

The physical characteristics of the device attempt to relate to a paper map, with some enhancements. It is small enough to fit on the handlebars, while large enough to provide ample display space. The device employs a touch screen to allow the user to easily provide input, as well as buttons which are detachable from the device and can be placed on the handlebars of the bike. Both the buttons and the touch screen are functional enough to complete all tasks independently of the other.

Rationale

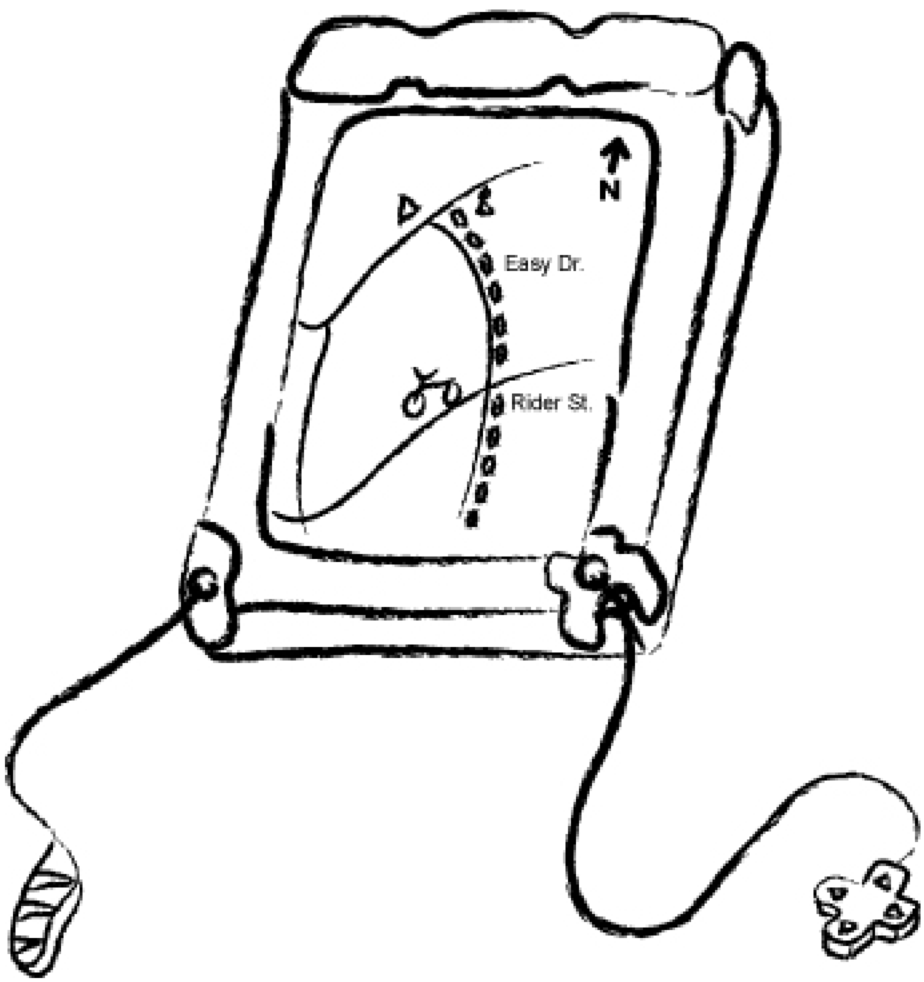
Many of the riders take a paper map with them and use it on the route, so this design is a natural step in solving the problem. It also was chosen because it meets a majority of the functional requirements and requires little training on the part of the users. Maptacular follows the route, allows the user to change/create a route, locate points of interest, and provides all of the other functional requirements. It is the most comprehensive system of all three designs as far as meeting these requirements.

An implementation of Maptacular will be able to meet the non-functional requirements, sturdy, lightweight, and waterproof. The only concerns are whether the display can meet different light conditions and withstand crashes.

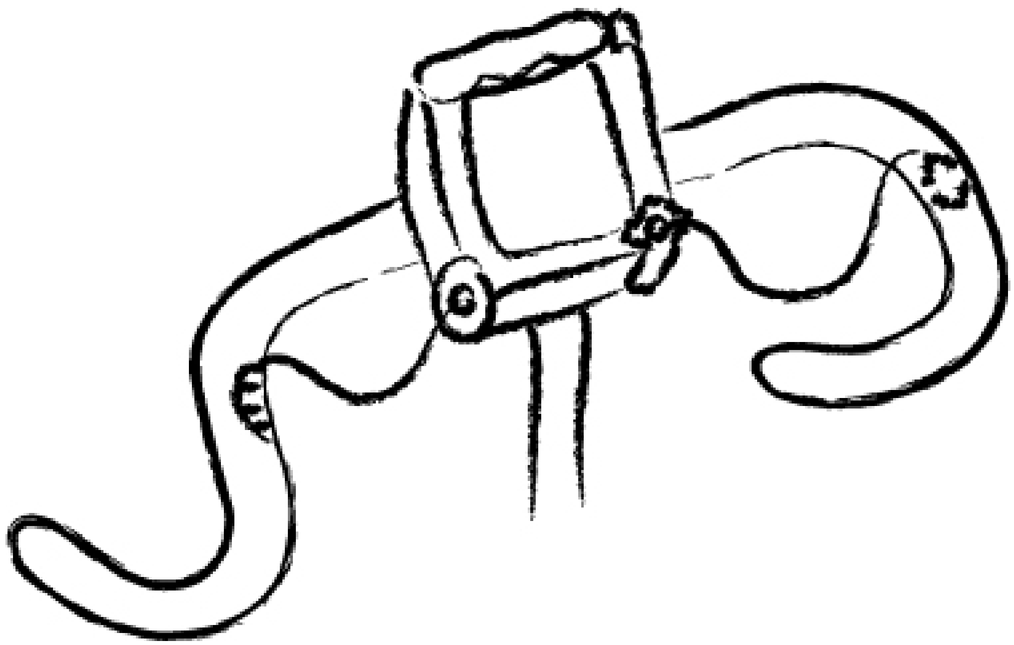
Often the tasks the user will want to perform include reading the map, finding the next turn, and looking for places to stop. While a paper map shows the area, Maptacular provides an easier way to interpret a map and the ability to change/edit a route. When a rider looks at a paper map, they must find their location on the map, the direction they are going in, the map scale and other pieces of information. Maptacular shows a small portion of the map, along with the rider's location, a highlighted route, and the next turn in an easy format to provide the rider with a quicker way to find information.

There are some criteria that the device is designed toward. The system is almost completely user-preemptive, supporting the criteria of dialog initiative. The user has the device run a task to collect information for the rider. Task migratability is also achieved, as the user can edit any route by changing one waypoint and allowing the computer to complete the rest of the route, or the user can select all of the waypoints. Many of the task for this system allow the user to enter as little or as much information as they want, and the system will complete the rest. Responsiveness can be determined upon further development of the design and depends on hardware specifications.

Illustrations

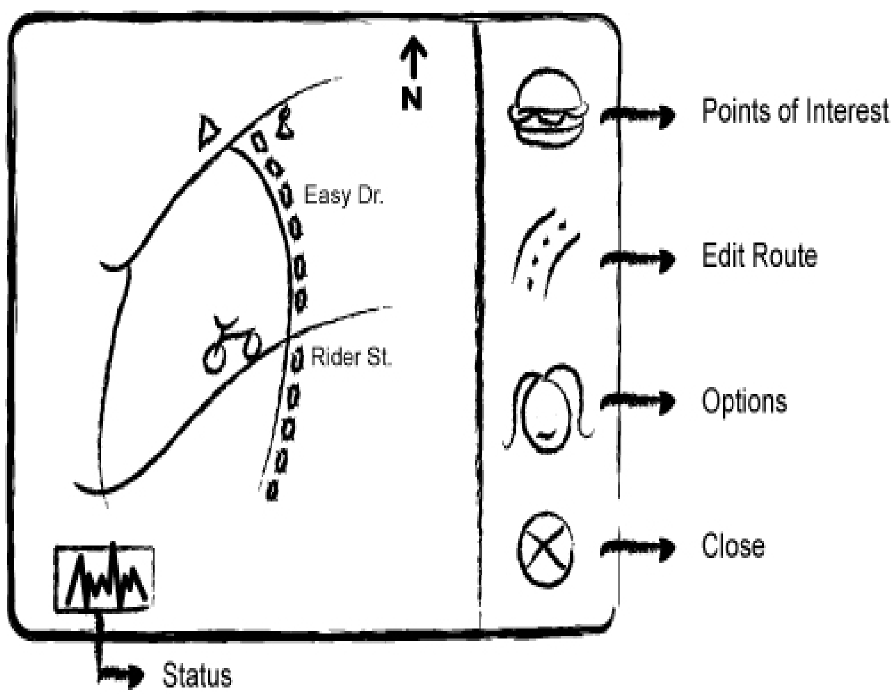


Device displaying a map. When the user is riding, the display will show a map of the area. The route the user is to take is shown by the dotted path. The rider's location is displayed by the use of a bicycle icon. The two buttons on the bottom of the device are detachable and can be placed anywhere by the user. The left button is a wheel similar to the ones located on a computer mouse. It is used to zoom in/out and select a menu option. The right button is used to pan the map by pushing on a direction. Along the top of the device are three more buttons to bring up the menu, an ok button, and cancel



The device on a bicycle. The device will be mounted on the handlebars of the bicycle by attaching the device to a thin pole which is connected to the handlebars. There is a space of a few inches between the device and the handlebars to allow the rider to place their hands in the center of the handlebars under the device. The two buttons are attached to the handlebars, but can be placed anywhere on the bike.

A user using the device. When users interact with the device, they will have to be looking at the screen in order to receive output. To give input, the user will hit the buttons.



Screenshot of the map mode with the menu. When the user hits the menu button (located on the top of the device), the menu is displayed. The user can then navigate the menu by using the zoom wheel or pushing on the screen where the icon is. Once they have their selection, they hit the ok button (unless the use the touch screen, in which case it is not necessary to hit the ok button).

The options button provides a large amount of flexibility for the user. Under options, users can set the size of the map, the granularity (how detailed the map is), and the orientation of the map.

Scenarios

Scenario 1

Lance starts a ride, gets sidetracked by something that interests him and/or is tired, and wants to return by cutting down the original route length.

Lance was ready to enjoy a new bicycle route on a sunny Saturday. He had spent a few minutes the night before entering the route “Stoney Brook” into his Maptacular system. After arriving at the starting location, he gets on his bike and turns on the Maptacular system. He is asked which route he would like to ride today, and selects “Stoney Brook.” The system loads the route onto the screen, along with an arrow for which direction he should travel in. Lance than begins to ride in that direction.

After a couple hours of riding, Lance sees a sign for the Mount Pleasant Winery and decides it is worth a visit. He doesn’t know the exact coordinates of the winery, and it is not listed as a point of interest in his device. But there are road signs that direct him to the winery. He begins to follow these signs, deviating from the “Stoney Brook” route in the device. The device warns Lance that he is going off the route, and continues to track his location.

Following a quick lunch and a few drinks at the Mount Pleasant Winery, Lance gets back on his bicycle. He decides that the winery was an interesting place, and wants to add it to the places of interest in the Maptacular. Lance hits the menu button, selects the places of interest icon, and then selects add and adds the Mount Pleasant Winery to the points of interest. Lance then is shown the way back to route, and he is on his way.

Forty-five minutes later, Lance has decided that he does not want to finish the route he is on. He hits the menu button again, and selects the edit waypoints option. He then sets the last waypoint as the next waypoint. The system then changes the route to show the fastest path between Lance’s current position and the finish point, where his car is. This cuts down the distance left in the route, which was 35 miles and is now 6 miles. Lance then finishes the route, gets in his car, and packs everything away.

Scenario 2

Lance has been riding for many years, and has been a ride leader for the past two. Today, he wants to go explore a new area and decide if it would be a good biking route.

When he gets to the location, Lance gets on his bike and turns on his Maptacular . When the Maptacular asks Lance for what route he would like to ride, Lance selects the No Route option. This displays a map of the area, and his current location. Lance was told by a fellow rider that route 66 had some excellent views. He locates route 66 on the map, and begins to head in that direction.

As Lance keeps riding, the Maptacular keeps track of his current route. Lance makes various turns on different roads, and continues to ride around enjoying the view.

After a few hours, Lance has completed his ride and returns to the starting point. He then saves the route with the name “Route 66”, packs up his stuff and heads home in his car.

After arriving home, Lance hooks his Maptacular up to his computer. He reviews the route he took today and decides that it was a good route. He then uploads the route to his website, where it can be shared with other Maptacular users. Lance also decided that he is going to lead a ride next month. He then advertises his ride on the Southern Bicycle League website, and exports the route from the Maptacular to a .jpg so everyone can have a copy of the map.

Assessment

Advantages

The Maptacular system is very similar to the current system used by modern riders. Most riders are familiar with maps, and by providing a visual interface similar to a map, riders may feel more comfortable trusting the device.

Maptacular also provides more information to the user compared to a paper map. Riders can view the map from their location to the nearest waypoint, or a 5 mile radius, or their whole route among other viewing options. Maptacular also provides an easy interface to change the current route by creating/deleting waypoints when viewing the map.

Users of the Maptacular system also do not have to wear the device. With the other two designs, users have to wear the device for an extended period of time. Some users may find these other devices uncomfortable or heavy and as a result may not use them.

Disadvantages

The Maptacular system can be distracting. The goal of the design is to let the rider enjoy the route by providing information on where to turn without interrupting the enjoyment of the ride. Some users may spend too much time reading the map or playing with the options, which would result in a lack of concentration on the road and a possible crash.

This system also can cause crashes. Since the riders have to look at the interface and remove their eyes from the road, they are more likely to crash into a tree or flip their bike over, and the system could be destroyed or damaged by the impact. The system’s weight may also be a factor. If the device is heavy, it may be difficult for riders to adjust to the new weight distribution of the bike.

Lack of system pre-emption. A rider can be on a ride, enjoying the scenery and not paying any attention to Maptacular. After a couple of hours, they look down at the screen and find that they are 25 miles from the route. The system needs to be able to notify the user of an upcoming turn and to be able to ensure that the user is aware of the upcoming turn.

One other interesting point is that the system can be very distracting to a new user. But if the user becomes accustomed to the device and begins to ignore it, they may miss the next turn.

User feedback

- Light device is very important
- Picture on display should not be too busy. Show only the most important roads, because there is no time to analyze a detailed map.
- There should be one general mode. People generally don’t like to change between different modes.
- External buttons are not needed.
- Zooming and scrolling should be done directly on a touch screen. You should be able to scroll around by moving your finger on the screen (compare to hand in Adobe Acrobat Reader)
- Changing the orientation of the map according to the current direction is a good idea. But it should also be possible to turn it off.
- Normally, only the current road and the important crossings should be displayed. But it should be possible to “call” the whole map, so that one can see more roads in the current region.
- Can’t look too long
- Boring is ok
- Riders have a sense of self-preservation

Design 2: Cycling Partner

Description

The *Cycling Partner* is a voice-based interaction system, which empowers the rider to ride safely and confidently. The metaphor applied is that of a cycling partner that the rider converses with along the ride, and he (the partner) is the one with the map. So the interaction comes naturally in terms of the rider asking the partner for pertinent information such as distance to next waypoint, current position, any known places to rest/eat, first aid points.

The proposed system is essentially housed inside of the biking helmet. The helmet is modified to accommodate a headset with a single earpiece and uni-directional microphone. Input to and Output from the system is completely auditory in nature. A single earpiece system is proposed so as to ensure that the rider's complete attention is not focused on the interaction with the system. Earpieces covering both ears could be problematic as then it would be difficult to attend to external sound/sound in the environment.

Riders use a computer to create a route - marking way points, places to rest/eat, first aid stops, and other points of interest. The route(s) are then downloaded onto the system using either infrared or a cable. A "Listen" command activates the system. An "Ignore"/"Lock" command lets the system know that any conversation henceforth is to be ignored, until another "Listen" command follows. A "List" command lists all possible avenues of action available to the rider in any given context.

The system has a contextual vocabulary and interacts in the format understood to the rider. "Listen. Directions?", "Next waypoint please" and "Distance covered?" are some of the commands the system understands. Its responses -"Turn left on to Peachtree Street", "Next waypoint is 2.5 miles away" and "Distance covered is 7.6 miles". The rider can perform a "Status" check on the batteries, the GPS connection, and on-route/off-route. A "Find" command issued gets the rider information on certain points of interests such as rest areas ("Rest area"), food stops ("Food stop") and first aid points ("Hospital").

Rationale

<u>Functional Requirements</u>

The functional requirements for the proposed system were for it to enable riders to complete a variety of navigation related tasks without having to go through significant change in the current school of thought. The riders should be able to use the proposed system to be able to do any of the following:

Know where he is, where he is going, take directions, change route in real-time, locate points of interest, download route(s), put device to sleep (save battery and also less distraction), lose GPS and still be able to follow map/guide, perform a status check (battery, connection, still on route/off route?) and receive warnings on the same.

The system affords for easy following of the route. Locating points of interest is only a “Find” command away. Route information is continuously recorded in the background. Download/uploading routes is using an infra-red communications port, which makes it a wireless affair.

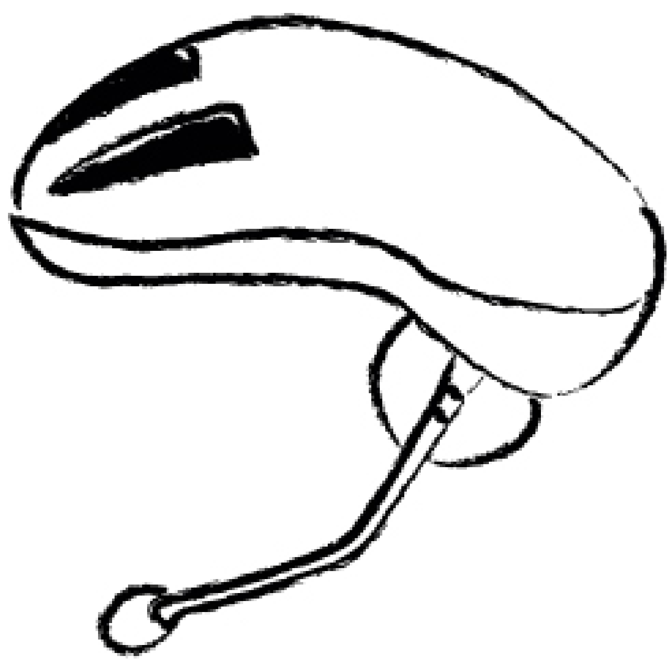
Nonfunctional requirements

The proposed system may provide information on distance covered and record route information. This would be useful for the rider to reflect upon when he/she is back from the ride. The idea is for the user to be able to reflect upon the ride, add more information to the route in terms of points of interest, see how long it took to ride it, and become aware about any differences between the map and the real route.

Usability Criteria

The proposed system device provides a natural form of interaction in terms of a speech-based interface. It is more akin to having a conversation with a cycling partner. Responsiveness of the device shall be roughly equivalent to that expected of a conversation, with a possible (slight) lag depending on the intensiveness of the conversation (command). The system is primarily user pre-emptive when it comes to disseminating information, unless the rider has to be reminded to take a turn or be warned about the status of any one system. Tasks can be migrated between the rider and the device in cases when GPS is lost, or when the rider wishes to change the route to suit his needs.

Illustrations



The computer is housed inside the helmet and the earpiece and mike are as seen. Provision will be made for the earpiece and mike to be transferred to either side depending on user preference.

Scenarios

<u>Scenario 1</u>

Lance starts a ride, gets sidetracked by something that interests him and/or is tired, and wants to return by cutting down the original route length.

Lance has a route he has wanted to go on for some time now. So he goes onto the internet, downloads the route on to his PC. Then he opens it up in the PC and adds a few waypoints he knows he would want to stop at, apart from the ones already on the map. This includes an eatery and a place that offers a great view of the surrounding countryside.

He takes off on the bike, with his gloves and helmet in place. He pulls down the microphone and says “Listen”. The computer comes alive and he asks for the “Countryside route”. He continues with “Next waypoint?”. The system replies, “Next waypoint is 2.3 miles. Take a left at Turnpike Road”. He continues along in this fashion when he arrives at the elevated spot from where the countryside is visible. He admires the beauty and decides to stay longer than planned. He gets off the bike, tells the computer to go to “Sleep”. He sits down on a rock and takes in the scenery.

He decides to walk a bit off the route and takes the helmet with him. After a bit of walking he realizes that he is slightly lost. He simply asks the computer to “Listen” and requests it to direct him to the closest waypoint (the place where his bike is parked). The computer directs him till he is back on track. He picks up his bike and proceeds onwards.

Before he reaches the restaurant (eatery), he realizes he is too tired to continue on the route, and asks the computer for a “Shortcut Home”. The computer analyzes current position and suggests a new route, which takes Lance home in good time.

<u>Scenario 2</u>

Lance is riding, loses the GPS temporarily and tries to keep on track.

Lance decides to take the bike out on a route into the hills. He gets on his bike and is moving along fine, asking at times for directions and at other times is prompted incase he veers off route or if there is danger of that happening. He checks the distance traveled by querying the computer for “Distance traveled”. Things look good for Lance so far.

He is busy concentrating on the scenery when the computer informs him that "Status check: GPS non-functional". He then asks for "Next waypoint?". Computer tells him, "Approximately 2 miles. Turn right onto Hunter's Trail". He travels 2.3 miles and comes to the turn. He then informs the computer of it, "At waypoint Hunter's Trail". The computer updates the route status and then informs him of the next waypoint.

After about 4 waypoints, the GPS connects and Lance is informed. He then lets the computer take over and take him all the way home.

Assessment

Advantages

Talking comes naturally to most people, and hence this is a system for them. The advantages being that a rider need not learn to talk to be able to use this system. The device will incorporate natural language processing to be able to understand most of what the rider says, making it an easy and fruitful interaction. This truly cuts down learnability time. The device being primarily user pre-emptive offers little distraction to the rider, making his ride safer. It does warn him incase he veers off the route or if some system critical function has failed. Lighting conditions do not affect our device.

Disadvantages

The disadvantage of the design is that it has only auditory interaction with the rider, and does not display any map. It's a 2 edged sword, and can go both ways. The device also makes it slightly difficult to alter a route, in the sense that the user is not visually able to see the alterations made in case he asks the device to do it for him. If he wishes to specify how he wants the route altered, he would need to have some prior knowledge of the roads ahead to be able to do so. Also, this system gives low level of detail about the current whereabouts of the rider.

User Feedback

The users we spoke to had different opinions.

One user said that the conversation mode could get distracting if the conversation is intense. He would prefer just terse/short commands given out and response taken in. The same user said that he would prefer a visual system, as he was more of a visual person. He also mentioned using a gyroscope to measure change in direction (as in a turn) so as to inform the system incase the GPS was down. Thus the rider might not need to tell the system he has turned at a waypoint even when the GPS is down.

Another user suggested the use of "Bone conduction" to replace the earpiece, as that would make it more comfortable for the rider in the long run, since having one ear covered is uncomfortable. Bone conduction uses vibrations on the skull to send sound to the eardrum.

Others we spoke to had mixed feelings about the device. Many said they would prefer it over others as it was the easiest to use by far, and the least distracting. It was the one which didn’t require much learning to take place to be able to use it. At the same time, some thought it would be difficult to know exactly where the user was at a given time. It could tell the user where he was, but many people relate to space through visual aids, and not having a map to see where they were could go against the device.

Design 3: Magic Glasses

Description

This design should allow the rider to fully concentrate on the road. The primary technology is a 3D see through display. Each eye has a slightly different image in order to see a 3D-image. There are also two cameras fixed to the glasses; these cameras capture the gesture of the rider as well as the road in front of him/her. The orientation of the head is determined by a 3D orientation sensor (in commercial 3D orientation sensors, they use a combination of a compass and gyroscopes). These sensors and the displays are wirelessly connected to a separate subsystem that controls the whole system. The rider can place this subsystem wherever he/she likes to have it. The glasses allow the user to see the real environment as well as a superimposed virtual image. Similar technologies are nowadays used in modern fight jets or in some Formula 1 racing teams. The devices can be fixed to the familiar outfit. They are also very light, so that the weight should not play a major role.

The idea is that the rider should see arrows virtually painted on the road; they show him/her the route. These virtual arrows are superimposed onto the road or the scenery. Also points of interests can be virtually marked (e.g. a billboard can show the way to a restaurant). If the rider would like to see a map, he/she can press the menu button that is attached to the glasses; then, the map mode can be chosen in the displayed menu list by “touching” the related menu item. The map only appears if you look down to the handlebar. Thus, the rider has to look to a place where a map is normally attached. The alternative of looking at the map could be very important if the system is somehow not able to track the position. If this happens, the user still has the possibility to find the route based on a conventional (but virtual) map. The user can virtually rotate the map with his/her hands because it is also very common to rotate a real map, so that your real view direction always corresponds to a bottom-up direction on the map.

The user input is based on recognition of hand movements. These gestures are recognized by two cameras on the helmet. The user can open and close menus by “touching” them in the displayed 3D-image. To see the menu options the user has to press a button that is attached at the side of the glasses. We chose this option (as opposed to open the menus with a special hand movement) because the users are used to press buttons to open a menu. Especially at the beginning, it could be difficult to learn a special hand movement to open a menu. It is much more straightforward to press the only available button. But if you see the menu options, it is very natural to point at an item, or to touch an item.

When the system starts up, it shows you a menu with two alternatives:

1. Saved routes (if you want to go for a ride)
2. Create a route (if the user wants to create a new route)

If the user wants to ride a saved route, he/she chooses option 1 and gets a list of all possible routes. The routes in the area, where he/she is currently, are highlighted, because those routes are more probable to be chosen. The rider chooses one route, and the needed information to find the route is displayed. While riding the rider can open the menu by pressing the button at the glasses. In this menu, the rider has additional options like changing the route, updating the route, performance statistics etc.

If the user wants to create a new route, he/she can do this on a PC and then download it to the navigation device (this is described in Appendix B). But the user can also ride a route in the record-mode, i.e. the system records the route that the rider rides. He/she can add points of interests to the recorded route data when he/she recognizes something that is worth to mention (e.g. food shop, toilet, machinist etc.)

As mentioned above, the user can access a virtual map. This could be very useful, if the rider wants to locate a point of interest, e.g. restaurant, bathroom, as well as to get an idea where he/she currently is on the route. And this map mode could be absolutely necessary if the system is somehow not able to track the user's position. In such a case, the system could be changed to this map mode.

Finally, if the user feels that the display is disturbing, it can be minimized; and it alerts the user when he/she approaches a waypoint with a small visual signal.

Rationale

<u>Functional requirements</u>

This design fulfills all the functional requirements. These functionalities are addressed in a way that accounts for the knowledge of the user. The user should be able to use the system with minimal amount of learning. We therefore used a number of metaphors, e.g. arrows, billboards or maps, which should ease the learning effort. Especially the realization of two important requirements, namely following the route locating points of interest, are virtually embedded in the real environment, which allows the rider to find the route and points of interest without any learning effort. The usage of metaphors for these two requirements is much stronger than in the other two designs. But also the other functional requirements are included in this design.

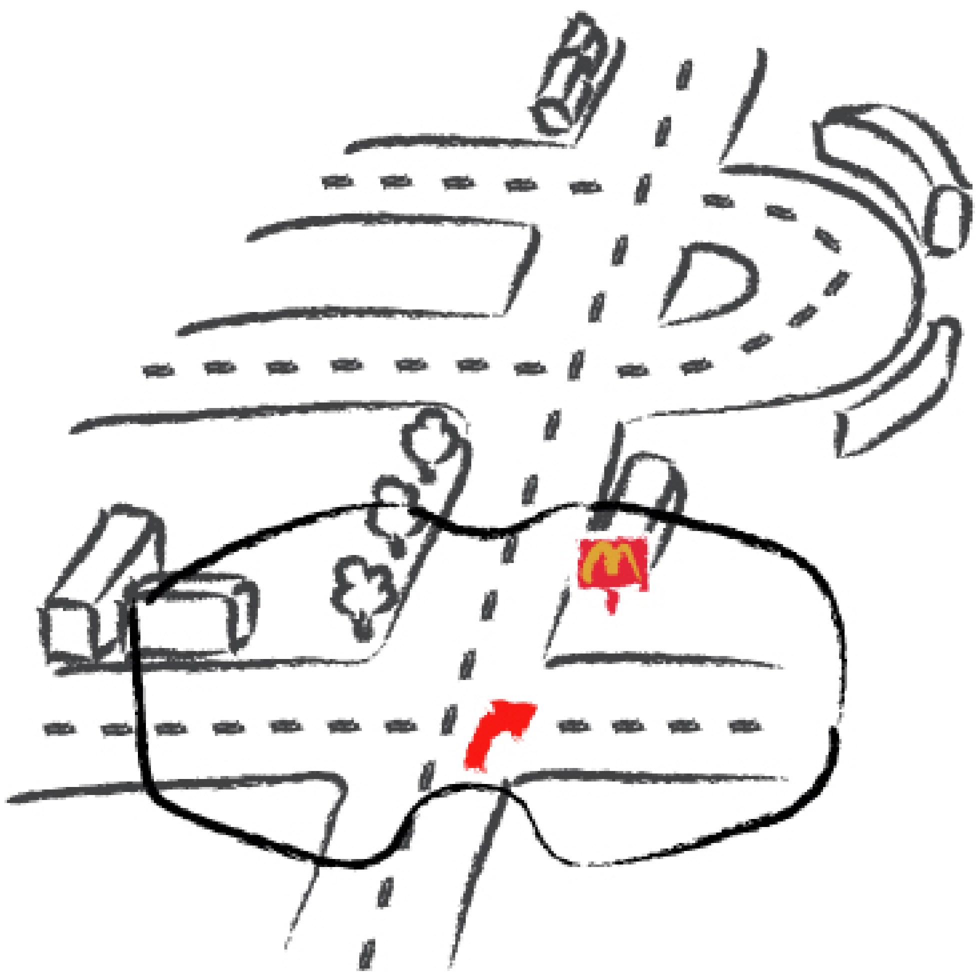
<u>Non-functional requirements</u>

A number of non-functional requirements have to be satisfied. It should be sturdy, lightweight, mobile, easy to setup, easy to use. In this design we address these requirements by integrating the system into the familiar device (e.g. glasses). It should be light enough so that he/she nearly feels anything unusual. The system "disappears" in the background. The system assists the user when needed, but not more. The system should not distract the user; the user should be able to enjoy the natural environment even more than before, because he/she needs less concentration for finding the route. Because it integrates the routing information in the real world, it should be very easy to use.

<u>Usability criteria</u>

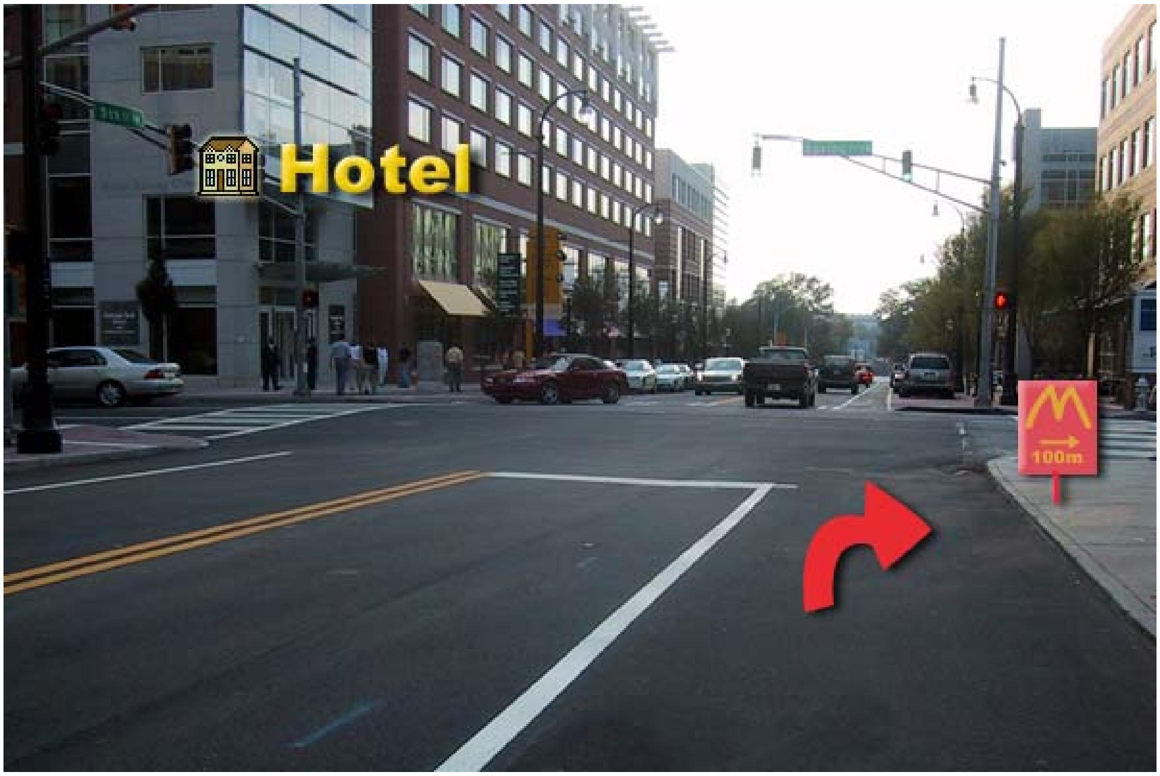
This design supports the tasks the user wants to perform in a very natural way; because the computer is a background assistant, the user gets the contextual information when it is needed and not more assistance than really needed is provided. The information is "delivered" to the user, so the user does not have to actively get the information. The control of execution can migrate. The user can take over certain system functionalities, for example by reading the virtual map. The user can reduce the system pre-emptive interaction to an absolute minimum. This design is a good way to minimize the feeling of the rider being dependent on the system, because the displayed information is not perceived as computer data; the information is integrated into the real environment; it augments the "knowledge in the world".

Illustration



The two cameras and the projectors are integrated in the glasses. The rider then sees the real world around him/her and the superimposed virtual information from our system. The superimposed information appears at the used places in the view of the rider, i.e.

direction arrows are on the road, billboards are on the side of the road or attached to houses.



This picture shows how it could look like from the view point of a rider. The real device would provide a 3D-image, of course.

Scenarios

<u>Scenario 1</u>

Lance is on a normal ride, gets tired and therefore returns without finishing the route.

Lance, a very enthusiastic rider, wants to go for a ride. He takes his helmet, his glasses and of course, his bike. He proudly turns on his new navigation assistant. He “sees” the different possible route names (he downloaded them before from his PC) and “touches” the desired one. He doesn’t know this route, but a good friend suggested it. The arrows appear on the road and he follows them. He agrees with his friend’s opinion; the route leads through beautiful scenery. Also the little restaurant at the wonderful lake that his friend was crazy about was easy to find; a virtual billboard has shown him the way. After having enjoyed the fresh fish, he is just too tired to proceed. And also the lake is too nice not to take a swim. However, when he decides to go on his bike again after an hour, it is already too late to finish the route (his wife is expecting him at home because they are invited at her parents’). So, he decides to go back home. He pushes the menu button to see the different menu options. He tells the system which way point he directly wants to ride to (to the starting way point). Half an hour later he is where he wants to be. The day is saved: He is happy because he was on his bike and his wife is happy because for the first time he is not too late.

Scenario 2

Lance is on his bike, but recognizes that the system is not working.

The next day, Lance is on his bike again. However, something is not working. After half an hour the systems stops receiving any position signals; this is indicated by a blinking status alert. No problem for him! He changes to the map mode: he presses the menu button and touches the map mode item. The virtual map appears on the handle bar. So, if he wants to read the map, he has to look down. A red point on the map shows him the last known position. This information makes it easy for him to find his current position. With his hands he virtually turns the map to the desired orientation. He can proceed on his ride. From time to time he touches the map at his current position; based on the known position, the system can show an appropriate section of the map. And even today he manages to be at home in time!

Assessment

Advantages

- Because the computer is in the background, the user is not disturbed by unnecessary interaction with the system; it is embedded in the natural environment.
- The system is able to augment the "knowledge in the world" in a very familiar way for the user because a lot of metaphors are used (arrows, billboards, signs).

Disadvantages

- To use the system the rider is forced to wear glasses.
- Perhaps, not every rider wants to ride in an environment that is enhanced with virtual artifacts.
- It could be difficult to set up the system so that the user gets a real 3D-image; it is user dependent.

User Feedback

Negative

- Too dependent on technology
- Glasses can be disturbing in certain weather conditions (e.g. rain)
- Gesture input should be substituted by button or voice input
- It is disturbing that there is always something unnatural in the view
- Glasses could be very dim

- It is troublesome to indicate the current position in the map mode
- You should not show the whole map in the map mode but only the most important roads
- The arrows on the road should be semi-transparent so that the rider still can see any obstacles
- It would be nice to see distance or other performance information on the screen (on the periphery of the screen)

<u>Positive</u>

- Easy to interpret displayed information
- No effort needed for navigation
- Easy to learn
- Little distraction
- Very obvious design

Modifications to Requirements Specifications and Usability Criteria

After working on the Design Alternatives, and getting user feedback, we discussed further the viability of our design options, and came up with some changes and some conclusions.

Our functional requirements, already based on user input, do not significantly change. What we have realized is that not all functions need to have the same importance at all times. Due to safety and practical considerations, some functions will operate while riding, while others should only operate while stopped. In particular, the user should not be encouraged to make major route modifications while riding, this is too dangerous. Simple changes, like a shortcut home, are practical, but more complex changes or inquiries should be done while safely stopped.

We also realized that each of our designs, while being very strong in some aspects of our requirements, was weak in others. As an example, Design 2, the Cycling Partner, is excellent in minimizing distractions, and can be fully utilized while riding, but it cannot provide the density of information, due to the serial nature and low bandwidth of speech interaction.

We decided to do away with the usability criteria Task Conformance. We realized that, of course the system should do what it needs to do, but the user does not necessarily have a pre-conception of how the system should work.

We also decided to modify the usability criteria Dialogue Initiative. We had concluded that the system should be very user-preemptive, but we have since realized that at least while following a route, our designs should be strongly system pre-emptive, and the user should be alerted about upcoming turns and stops, instead of requiring him/her to look for the information.

Although we have not yet chosen a design, the information we have gathered from our users, and our own assessments, lead us to believe that the best design may be other than the ones we have described herein, and will possibly be a hybrid of these.

Appendix A – GPS

When people talk about "a GPS," they usually mean a GPS receiver. The Global Positioning System (GPS) is actually a constellation of 27 Earth-orbiting satellites (24 in operation and three extras in case one fails). The U.S. military developed and implemented this satellite network as a military navigation system, but soon opened it up to everybody else.

A GPS receiver's job is to locate four or more of these satellites, figure out the distance to each, and use this information to deduce its own location. This operation is based on a simple mathematical principle called trilateration. Once the receiver makes this calculation, it can tell you the latitude, longitude and altitude (or some similar measurement) of its current position. To make the navigation more user-friendly, most receivers plug this raw data into map files stored in memory.

A standard GPS receiver will not only place you on a map at any particular location, but will also trace your path across a map as you move. If you leave your receiver on, it can stay in constant communication with GPS satellites to see how your location is changing. With this information and its built-in clock, the receiver can give you several pieces of valuable information:

- How far you've traveled (odometer)
- How long you've been traveling
- Your current speed (speedometer)
- Your average speed
- A "bread crumb" trail showing you exactly where you have traveled on the map

Most receivers have a certain amount of memory available for you to store your own navigation data. This greatly expands the functionality of the receiver, because it essentially lets you make a record of specific points on Earth. The basic unit of user input is the waypoint. A waypoint is simply the coordinates for a particular location. You can save this in your receiver's memory in two ways:

- You can tell the receiver to record its coordinates when you are at that location.
- You can find the location on a map (the internal map or another one) and enter its coordinates as a waypoint.

This capability lets you use your GPS receiver in a number of different ways. You can record any specific location that interests you so you'll be able to find it again at a later time. This might include:

- Good camp sites
- Favorite road-side shops
- Excellent fishing spots
- Scenic overlooks
- Where you left your car

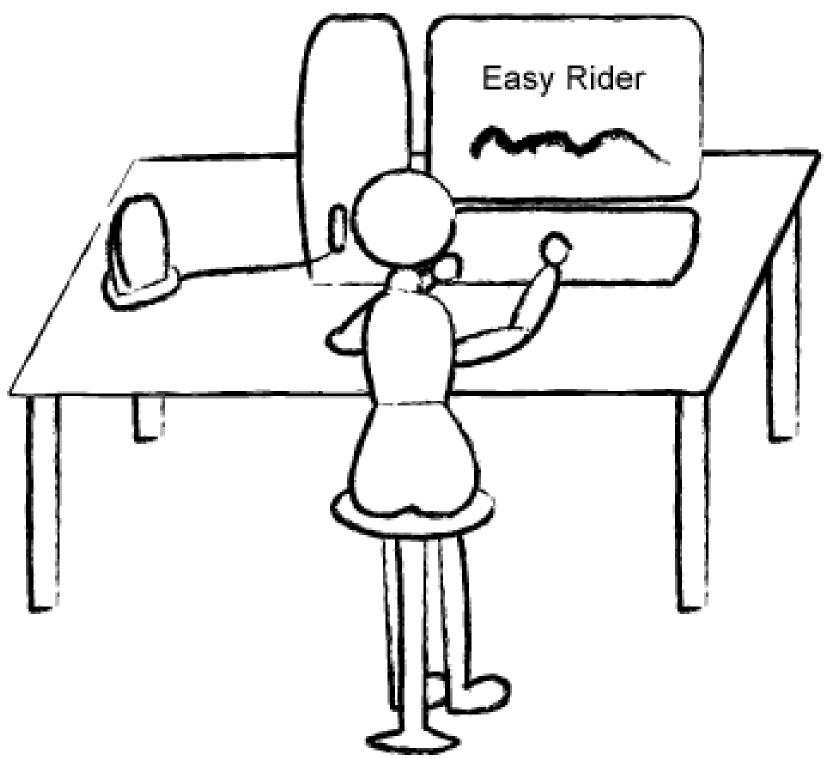
You can also combine a series of different waypoints to form a route. One way to use this function is to periodically record waypoints as you make a trip so that you can backtrack, or follow the same route again in the future. Route-mapping also lets you plan ahead: When you have time to examine a map at home, you can record a series of waypoints along the roads or trails that lead to your destination. Then, when you're traveling, all you'll need to find your way is your GPS receiver.

If the receiver has a data port, you can also download your routes to a computer, which has much more storage space, and then upload them again when you plan to follow those routes. Computers can do a lot more with GPS location data than your average receiver, because computers have much more memory and much faster processing capabilities. You can also update your computer maps easily, so you can include any surveying adjustments or changes in an area.

Appendix B – Mapping System

Following is a summary of the functionality:

1) Connect to Internet
2) Download information from the Internet
    - Updated map(s)
    - Location of resources
    - Pre-defined routes
3) Upload information to the Internet
    - Pre-defined routes
4) Create routes on electronic and map:
    - enter waypoints
    - select destinations
5) Connect to the device (our design)
6) Download information to the device
    - Updated map(s)
    - Route (waypoints)
    - Resource information
    - System updates
7) Upload route information from the device:
    - Recorded waypoints
    - Times and distances



User hooking the device up to their computer. Users will be able to connect their device to a computer. From here they can download/upload new routes, edit routes that are stored, and create new routes using a more functional interface (the pc software).

Appendix C – Further exploration of the design space

Parameter	Description	Range
Output	Device to user	• Visual • Audio • Tactile
Input	User to device	• Manual • Voice • Hand movements • Stylus
Visual Output	Information displayed to user	• Map • Cues • Text
Audio Output	Audio information from device to user	• Non-speech • Speech
Tactile Output	Tactile output	• Vibration
Visual display mode/device	Type of visual display from device to user	• 2D lcd display • 2D direct eye projection • See-through glasses with augmented reality • Left and right arrows using led displays
Sound output device	Device to user	• Speaker on device • Speaker on helmet • Ear bud • Bone conduction
Manual/Tactile controls	User to device	• Pushbutton • Wheel • Toggle • Joystick • Touchscreen
Mobility	Where to mount device (or portions of)	• Bicycle • Helmet • Rider • Glasses