An Interactive Appliance for Individual Well Being

Mechanical Engineering 310 Fall Design Document

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1 摘要

Example text

在开放性较大的大学校园里，对环境陌生的人群往往需要一定的辅助来了解校园的设施、结构等信息。

就需求来讲，某个特定的场所可能有诸多的信息需要开放介绍，甚至需要对来访人员进行一定的导航、指引，而通过单一的静态信息可能无法达到较好的传递效果，以此为出发点，我们力图构建一个系统来改善诸如此类的信息展示功能。

对于这种有效信息的获取，其渠道是多元化的，在远程呈现的应用可能下，我们可以将其作为一种获取方式进行设计。让身处远方的“参观者”能够“身临其境”的感受环境，也即通过实时远程传递音频、视频等信息，并且让使用者“自主”的去寻找他们感兴趣的信息。同时，这种功能不只是单向的，通过远程呈现的平台，可以实现两地的人员的实时交流、咨询，也即实现一定的“虚拟出席”的功能，用以辅助环境信息获取的效率。

一个可以令人感兴趣的设计是一种集散控制的导航、参观系统。

旨在某一建筑物中配置一套机群，其移动终端为可移动的并且具有网络传输功能的“远程呈现机器人”，其基本功能是代替参观者虚拟出席到特定环境中，并获取基本的环境信息，对于移动性的控制，一方面可以由非现场的参观者通过某一指标（比如一张平面图的点击）来安全的（操作上存在一定的必要限制）控制移动，另一方面可以由现场人员在移动终端上直接输入指令进行辅助控制，该辅助控制也可以通过前述的平面图点击来封装化的实现。

这一套散布式机群的远程命令获取，是通过一台服务器的命令转发来实现的，用户通过网络与服务器建立连接，发送给定的指令，服务器负责将指令集中，转发到分散的特定的远程呈现机器人终端，这一设计便是集散式的系统分部。

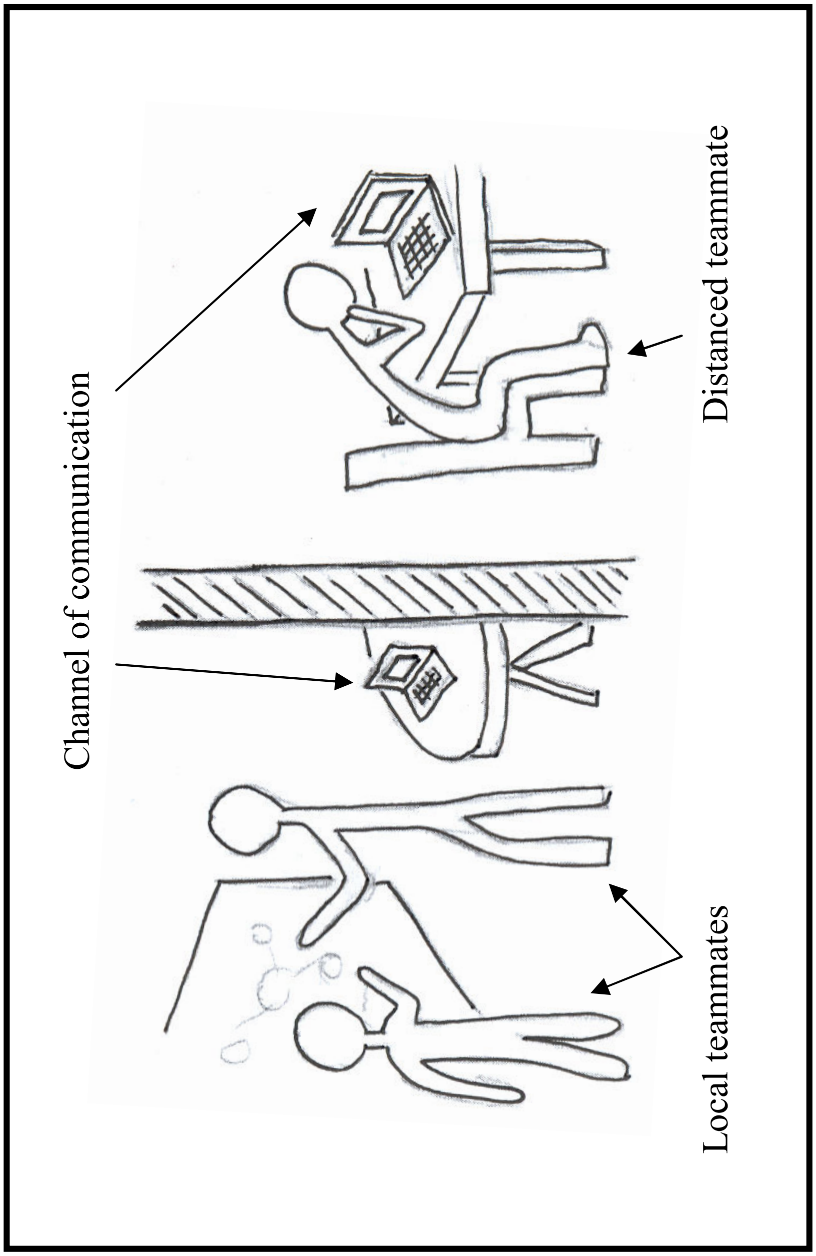

Figure 1.1: *Common result of destributed design meetings*

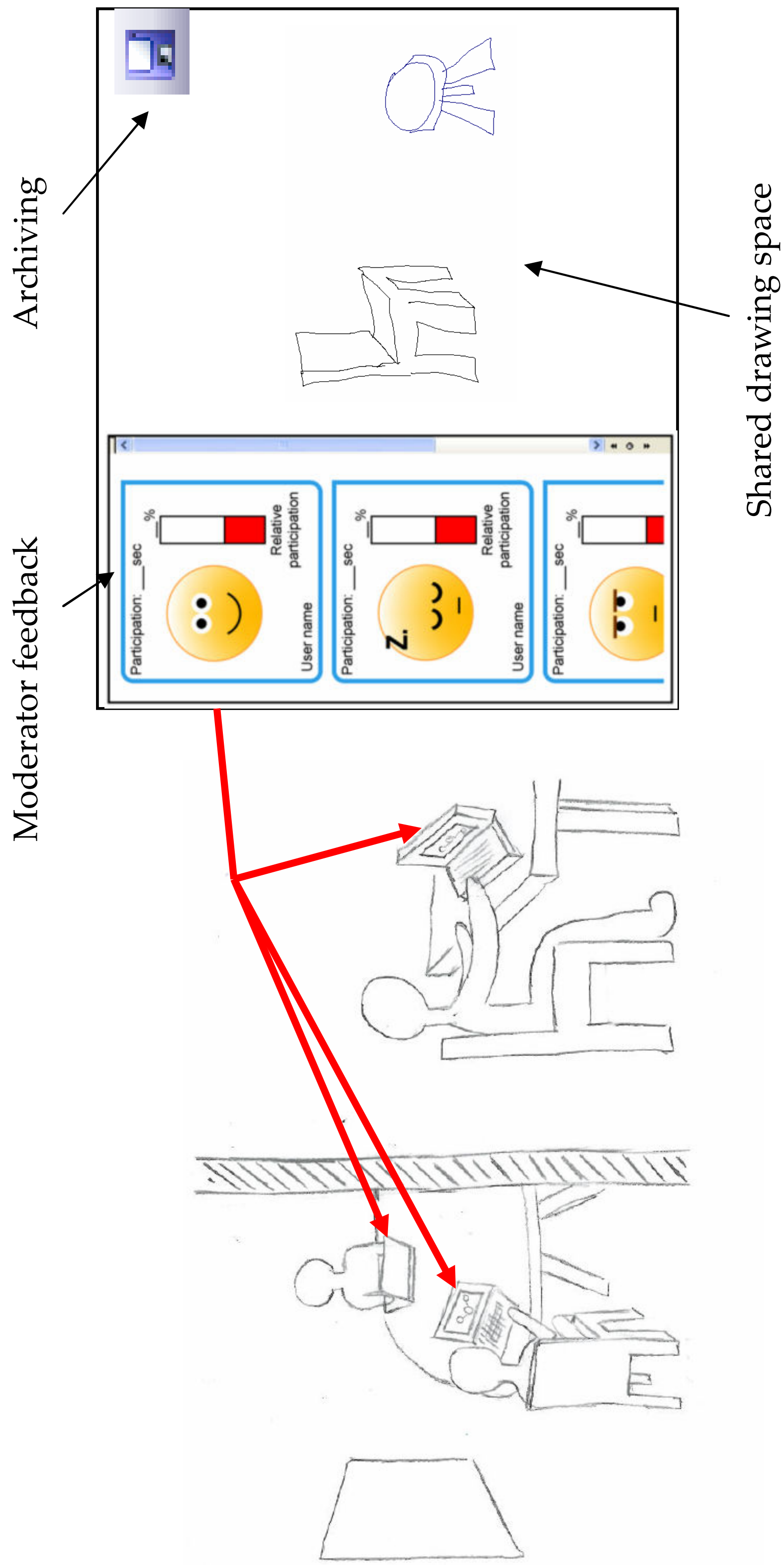

Figure 1.2: *Vision for a more effective distributed design meeting*

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Glossary

远程呈现 **(telepresence)** 是一种虚拟实在，能够使人实时地以远程的方式于某处出场，即虚拟出场。此时，出场相当于" 在场"，即你能够在现场之外实时地感知现场，并有效地进行某种操作。

集散控制系统 **(Distributed control system)** 是以微处理器为基础的对生产过程进行集中监视、操作、管理和分散控制的集中分散控制系统，简称 DCS 系统。

2 背景

2.1 需求陈述

随着计算机、互联网技术的飞速发展，人与人、人与事物之间的联系日益密切，人们所接触的范围也逐渐广泛起来，于此同时，所需要的信息流量也会大大增加，传统的传递方式也许并不能很好的起到传递效果。如果让数字化介入其中，便会收获更好的结果。

试想一下，当某一个机构或部门需要向外界介绍他们的相关信息，这些信息会给参观者留下非常重要的印象，如果诸如此类的信息能够具有实时性、全方位性，并且能够充分调动参观者的主观感受，那么这些信息的价值便会大大提升。

通过远程呈现的基本构架，借助移动机器人提供的主观能动性，搭建如此的一个集散控制的参观导航系统，便会具有如上所述的极佳的效果。

当你身处千里之外，通过简单的互联网界面，点击鼠标、敲击键盘，就可以达到参观目的地的效果，而且这种信息的获取是实时动态的，该是一件多么惬意的事情，你一定会对目标地点有一个非常好的主观印象。而且，你还可以随时与那里的工作人员等互动交流，岂不是更加便捷、实用！

2.2 问题陈述

进一步分析目标，我们可以将过程中需要着重注意、解决的难题归纳总结，分成不同的项目部分，以备后续逐步实现预订功能。如下为分类：

- 网络连接搭建的方式
- 远程操作者的使用界面
- 机器人上显示界面
- 机器人的具体控制方式

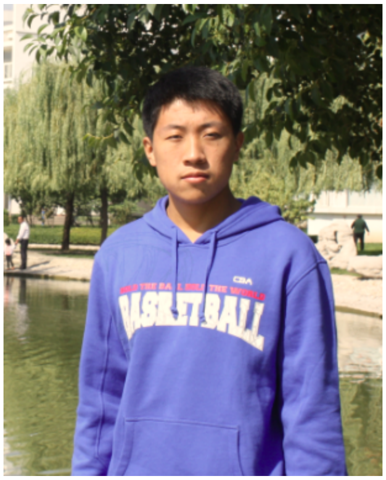
对于网络搭建，由于之前的机器人必须通过附带的可执行文件来建立连接，而且 ip 地址是内网中的，这一限制对于我们所设想的系统有较大的限制，因此这一方式必须得到改进，使得连接建立简洁、可靠、广泛。

对于界面的设定，由于跨平台的优势，应该是基于网页界面的设计，具体的功能模块后续的设计中会逐渐添加，进而集成到界面中，以达到符合用户使用需求的目标。

机器人的控制方式也是一个非常重要的方面，他直接关系到了机器人的安全性等强制性的因素，而且对于用户体验也是至关重要的。

2.3 组员介绍

Team *Papier Mâchè*, was assembled by the ME310 teaching staff, based on the outcome of Myers-Briggs personality tests (see Table **??**) and a desire to create teams with a diversity of interests and backgrounds. There is some evidence that such diversity enhances team creativity [**?**] [**?**], even if it creates additional challenges for team management.



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编程： C 语言编程， 初步 C++ 面向对象编程，matlab

来自山东，2010 年考入中科大信息学院，后就读于自动化系。喜欢设计，并且具有一定的动手能力，2012 年暑期与同学组队参加过 Robogame 机器人大赛，并最终获最佳技术奖单项奖。课余时间比较喜欢参与一些运动以及益智类的活动，热爱乒乓球、篮球、羽毛球、游泳等运动，对魔方速拧还原有一定的研究。

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3 Design Requirements

The remainder of this section contains sample requirements (not an exhaustive set but enough to give an idea) from Autodesk Fall 2007-08 [?] and Audi Fall 2008-09 [?].

Introduction

The Autodesk collaboration tool must enhance communication between groups of distributed engineers as they engage in brainstorming. We have focused on enabling this collaboration via tools that:

- Enable users to communicate naturally and through multiple channels.
- Enable the team to better utilize their teammates, be they local or distant.
- Capture the information that was presented.

Our benchmarking and prototyping efforts have led to a more detailed definition of what the product needs to be in order to successfully achieve this. The requirements address what the product functionally needs to do and what it physically needs to be. Because of the wide range of functional opportunities that exist for the product, few physical restrictions are imposed at this stage in the design.

3.1 Functional Requirements

Requirement	Metrics	Rationale
a brief description of what the requirement or objective is	measurable quantities associated with requirement (how to assess if a design satisfies the requirement)	why this requirement is important or valid

Table 3.1: *Three column format suggested for requirements (One can make a separate table for each cluster of related requirements).*

Requirement	Metrics	Rationale
The product will balance the number of interactions in distributed design meetings among the team members.	Interactions are questions or statements that develop a concept. The total number of interactions per person during a design meeting will be called n_i. The solution must reduce the standard deviation of n_i between team members as compared to the closest publicly-available competing product.	The number of times someone interacts in a meeting is one measure of engagement. Brainstorming is a highly social process which thrives on the input from a variety of perspectives. By effectively improving the communication between distributed teams, team members will be more engaged and participate more.

Table 3.2: *Requirement for improved communication*

3.1.1 Functional constraints

3.1.2 Opportunities

- Utilize existing tools. There are many collaboration and input tools that exist out there. Our product does not need to be a replacement for them. It could potentially supplement them.
- Offer new lines of communication:
  - Facilitate side conversations between distributed users.
  - Utilize the uncrowded channels offered by other senses than audio/visual, such as tactile.

Requirement	Metrics	Rationale
The solution must transmit sound at close to the rate of normal conversation.	The listener must hear the speaker with less than 0.3 seconds lag.	Audio latency creates a sense of distance. Mobile phone to mobile phone conversations have an average latency of 0.3 seconds, which is noticeable but not disruptive.
Users can capture drawings to share with distributed teammates that are legible.	Input device must be able to resolve a drawing at 50 points per inch (specifically, they must capture 50 percent contrast modulation at this frequency).	Drawings by mechanical pencil and ball point pens typically have lines of 0.5mm thickness, which translates to a resolution of 50 points per pinch (ppi).
Users will be able to capture drawings to share with distributed teammates without disrupting the flow of the discussion.	Drawings must be captured and sent within 17 seconds. This is assuming the input device is properly set and there are no external complications.	We found through benchmarking that sketches are used primarily when describing a concept, and are of little use afterwards. The sketches must be captured and sent before the context of the discussion has changed. Seventeen seconds was found to be about the average comment length during brainstorming in our prototyping.
Users will be able to see the drawings clearly.	Drawings must be displayed with a resolution of at least 72 ppi.	The display must be able to resolve at least as a standard computer monitor.

Table 3.3: *Required mediums of communication for effective concept development*

- Be the moderator:
  - Collect feedback from users directly, via voting, or indirectly. Enable the replacement of video, which conveys very little useful feedback during design meetings.
  - Encourage the participants to be engaged by monitoring participation.
  - Display feedback and participation to attendees non-verbally,potentially through the use of avatars.
- Allow for easier information capture and storage
  - One button information capture
  - User-driven archiving
- Assist user communication in non-native languages.

Requirement	Metrics	Rationale
The tool must be able to be started up quickly for impromptu meetings.	It must be able to be started in less than 40 seconds. This time is calculated from the moment someone decides to start the system, to the point when the tool is ready to use, with full functionality. If the solution requires use of personal laptops, assume these are already booted up.	Our benchmarking has shown that collaboration tools can fall into disuse if it requires a lengthy setup time. This amount of time is within the range of initiation times for multiple popular conferencing solutions.

Table 3.4: *Social requirements for effective design meetings*

Requirement	Metrics	Rationale
The bandwidth required must not be prohibitive to standard engineering offices.	The product will require less than 100 Mbps.	The population of potential users would dramatically decrease if the product required more connectivity than a T1 line, which is typically around 100 Mbps.

Table 3.5: *Functional constraints*

  - Audio buffering

- The product should be accessible
  - Usable for low bandwidth connections for
  - Be fast to setup.
  - Able to be setup within a typical conference room.

3.1.3 Assumptions

- Each user has, and is able to use:
  - a personal laptop
  - a mouse
  - a microphone
- Users will speak with a volume of at least 30 dB, as measured when 1 meter from the microphone.

3.2 Physical requirements

For variety, here is a requirements table from an Audi fall document [?] done in MS Word and pasted as PDF into Latex. Notice that the fonts are scalable if you zoom in.

Requirement	Metrics	Rationale
Relevant controls should be within reach of the driver and front passenger	Users must be able to reach controls without having to lean.	In order to allow for minimal distraction while driving, user should not need to shift positions.
Controls should be comfortable to use.	Users will report no feelings of awkwardness or fatigue from trying use the controls. Buttons will push down with a reasonable amount of force.	Users will not want to use a system that is uncomfortable.
System interface should be distributed throughout the vehicle.	Controls will be spread out over the cockpit.	When all the functions are combined into one control, the system becomes too complicated to use, resulting in a steep learning curve.
System will retain the Audi "genes"	Integration of the interface will allow previous Audi drivers feel like they are just in another Audi	Users like consistency. A vehicle brand should be dependable, in-line with its current look, feel, and overall theme.

Table 3.6: *Physical Requirements from Audi 2008-09*

4 Design Development

The broad scope of our problem statement allowed the team members to use their imaginations and arrive at creative solutions. We drew from our diverse individual experiences to redefine the problem as we learned more about existing collaborative tools and practices. Throughout the design development process we balanced pushing forward with our current ideas while constantly looking for new directions.

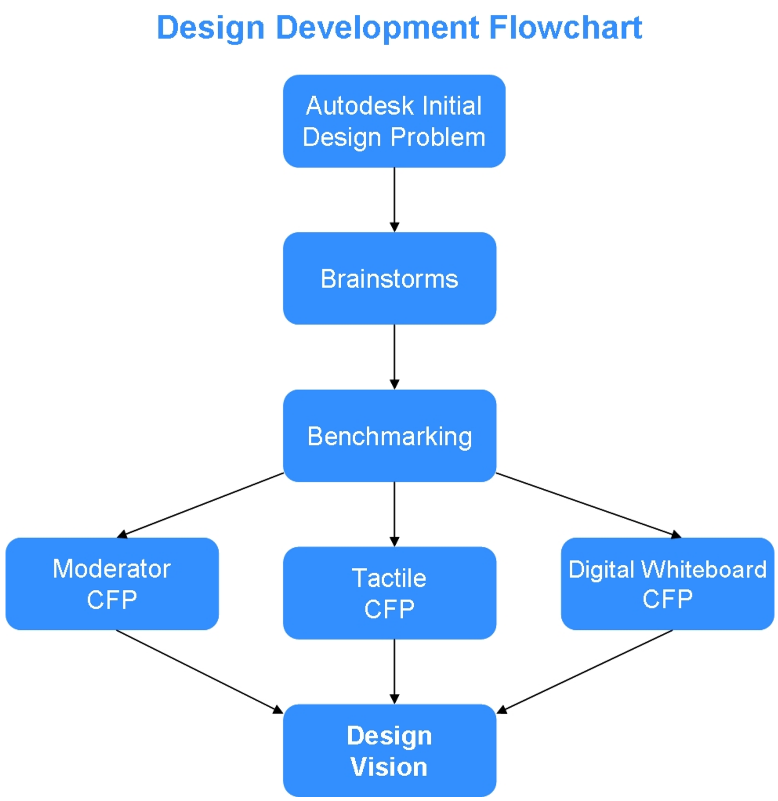

Figure 4.1: *The design team's development process.*

4.1 Brainstorming

Our experience in brainstorming was unique in that we were observing and studying our own behavior while exploring solutions. We were constantly studying our own triumphs and shortcomings in the hopes of gaining insight into team dynamics. The results of our multiple brainstorms throughout the fall quarter can be into categorized the following categories:

4.1.1 Communication

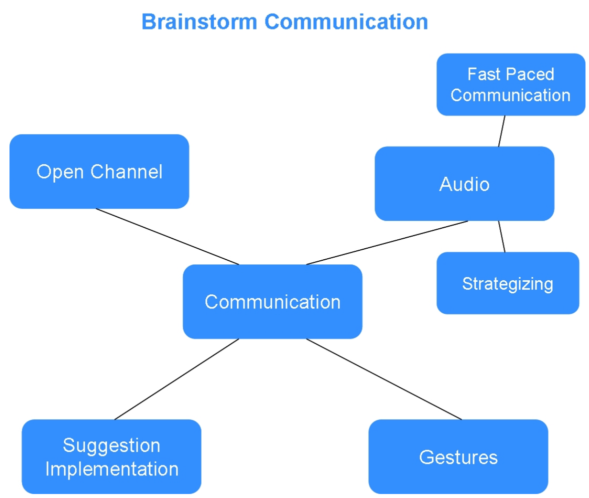

Figure 4.2: *Key components of communication in design meetings*

- Open channels
  - Audio and video channels are often inundated with information, even if they are not the most effective means to transmit a piece of information. The team learned that messages are most clearly conveyed when they are free from interference.
- Integrate suggestions quickly
  - People can build onto other's ideas immediately, and rapidly change the direction of the conversation.
- **Verbal communication is the most flexible**
  - The team learned from their experience playing cutting-edge multiplayer videogames that verbal communication was the most relied upon medium during fast and slow paced activities. It's versatility and low-bandwidth warranted future attention.
- Gesture
  - Gesture is frequently used when explaining an idea. Often, the drawings produced do not look at all like the concept being developed, but the act of drawing in and of itself can be like a gesture, showing how something will work, or where it will be placed, and so forth.

The rest of this subsection is omitted for brevity

Some key realizations from the brainstorming phase were that social factors and communication shortcomings had alot of opportunity for development. We decided to give special attention to social benchmarking in addition to our technological research.

4.2 Research and Benchmarking

The team's research and benchmarking efforts were focused on three major categories: human-machine interfaces and input devices, social dynamics, and communication. The methods the team utilized to research items in these three main categories included trying out hardware, drawing on previous experience, participating in improv exercises, researching existing solutions, and speaking to experts from design, neuroscience, and computer science.

4.2.1 The Nintendo Wii ®- Accelerometer-based input)

Figure 4.3: *People playing Wii Sports on the the Nintendo Wii ®. Ideally there would be a citation to the URL this photo came from.*

The team investigated some unconventional means for data input. Gesture-based input devices like the Nintendo Wii controller offer the possibility of an intuitive, and compelling way to interact with someone at distance via digital means. For navigating through Windows or other applications, the team found the Wii to be more challenging than a conventional mouse. Accelerometers are adept at capturing large motions rather than precision pointing and would need to be utilized as such. Potential applications could be for interfacing with avatars or tactile feedback systems. The Wii controller could be used as a gesture-based communication device to control a personal avatar or send and receive tactile messages.

Key lessons learned

- Accelerometer based input devices could be used in gesture-based or tactile communication, but do not fare well in precision pointing.

- Gesture-based interfaces generate excitement. People want to use input devices that respond to gesture.

4.2.2 CyberGlove ®

Figure 4.4: *CyberGlove ®gesture-based input device. Ideally there would be a citation to the URL this photo came from.*

The rest of this subsection is omitted for brevity

4.2.3 EEG and Participation Monitor

Figure 4.5: *Example of the first available wireless EEG tool, made by IMEC. Ideally there would be a citation to the URL this photo came from.*

The team met with Alicia Warlick, a researcher in the Stanford Neuroscience Department, and her research in monitoring brainwaves. We discussed the possibility of monitoring whether meeting participants were actively paying attention by using an EEG. This is a method for measuring the activity level of the brain. There is opportunity to use this as a metric for testing our final product, or potentially in the product itself as a means to collect data on user participation level.

Key lesson learned

- Electrodes could be placed on the users forehead and scalp to measure EEG readings, which conveys information about whether someone is engaged in what they are doing, or if they are withdrawn.

The rest of this subsection is omitted for brevity

4.3 Critical Function Prototypes (CFP)

The initial benchmarking phase lead the team to realize that there were three major challenges to solve: bridging the proximity gap, moderating brainstorming, and conveying and recording ideas. The team decided to tackle all three of these major challenges and designed four CFPs in an attempt to solve, or at least start answering some of, the questions these challenges brought up.

4.3.1 Tactile CFP

4.3.1.1 Tactile CFP Concept Development

The team wanted to come up with a creative solution that would enhance distance communication. Although we identified software having an important role in our solution, we wanted to try to design something physical. We had to answer these questions that were raised after the benchmarking process:

- How can we simulate proximity for remote meetings?
- How can we implement action-event control?
- What senses can we stimulate that aren't normally used?
- What is a low bandwidth solution?

The team decided that building a tactile messaging system would solve all four of the aforementioned questions. Tactile messages could replace common interpersonal interaction found in same room meetings. It is normal to welcome each other with a handshake, make eye contact throughout a meeting, smile at each other, and give high-fives to congratulate others. These occurrences are all absent from distance meetings. A tactile message corresponding to each of these gestures would allow users similar opportunity to communicate as if they were sharing the same physical meeting room.

The team learned that immersive activities like videogames take advantage of action-event control to offer users a seamless means to interact with their environment. A tactile message could quickly be sent over an open channel and pressing the on button would instantly message the recipient.

Out of the five senses (sight, hearing, taste, touch, and smell), sight and hearing are the most relied upon during meetings. The team considered possibilities in taste and smell messaging but continued with touch, since delivery of tactile messaging was much more straightforward. Since conventional distance meetings only send and receive auditory and visual information, tactile messages would be distinct and easy to identify. The team believed that tactile messages (high, low, or off) would be low bandwidth.

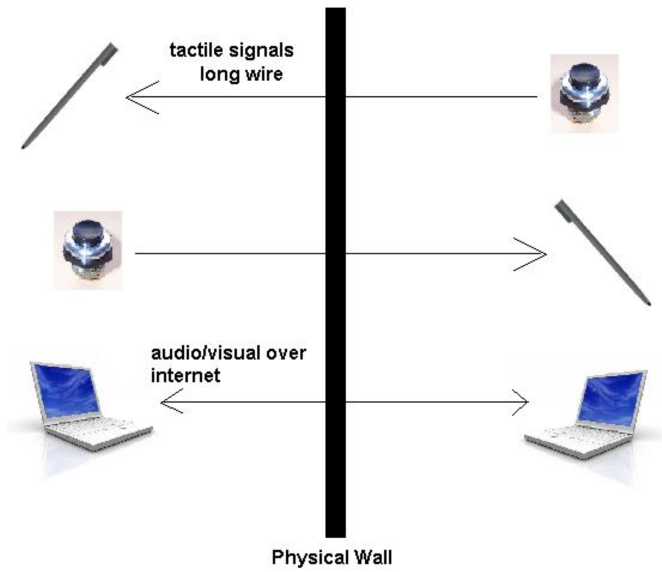

Figure 4.6: *The team's whiteboard during a brainstorm session*

The team wanted to test the effectiveness of tactile messaging and decided against a TCP/IP protocol that sent messages between Stanford and PUJ. The code to write such a protocol was extant and it was unnecessary to include it in our prototype. The team simplified the setup and created two stations separated by physical barriers (a wall and 50' of distance), to simulate a distance meeting. Each station would have a vibrating tactile device for each seated participant at that station and a high/low button assembly to activate the vibrating tactile device for each participant at the other station. Initially the devices were supposed to operate as "on" or "off." The team decided that having more variability in the operating speeds of the motors would increase the number of different messages that could be sent, and added a high and low voltage button (1.2V and 0.6V). We were curious to see if effective communication could take place if a distant colleague could see what sketches his distant colleague was drawing. To test this, we used webcams to send live video of what the participants drew on their drawing pads to the other stations.

4.3.1.2 What is critical about this CFP?

The team identified these questions as critical before testing:

1. Can it create immersion?
2. Does it improve upon existing communication tools?
3. Is it easy to understand?
4. Is it intuitive?

5. When should it be used?

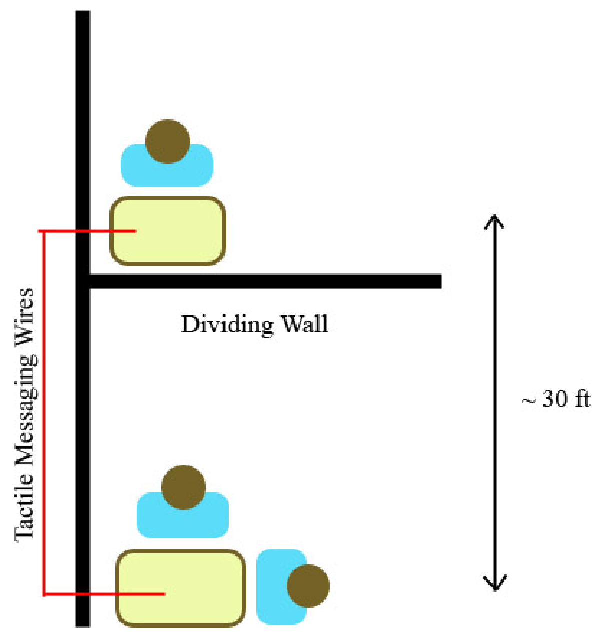

Figure 4.7: *The orientation of the two tactile messaging stations.*

4.3.1.3 Lessons Learned

Tactile sensation is an effective means of communicating contextual information. The messaging system delivered instant vibration between the two stations, helping preserve the flow of conversation without impeding it. Using the vibrations to alert the other users that you wanted to say something was a good way to make comments at the precise time you intended. The tactile devices were **easy to use** and the participants were encouraged to use them as they saw fit. We noticed that **vibrations were used most frequently to add emphasis** to accompany laughter, to confirm agreement, offer praise for a good idea and to interrupt the speaker. Interruptions consisted of calls for clarification on a point raised or disagreement with an opinion. Interrupting someone who is speaking can cause the speaker to lose his train of thought or become otherwise agitated. We noticed that **users preferred to send low speed vibrations** as a gentle interruption as a first attempt to get the speaker's attention. If the first few low speed vibrations did not stop the speaker, the high speed vibrations could be sent, and these usually registered right away. We observed that users reserved high speed vibrations for urgent or important messages.

The signals were mostly easy to detect, but it was **not always clear what those signals were trying to communicate**. Ambiguous or superfluous signals distracted the receiving user from the meeting and the confused user would ask, "Did you just buzz me?" or " Why did you buzz me?" These confused questions would stall the meeting for everyone until the sender was revealed and was able to explain what they were trying to communicate.

Vibrations, however, were easily detectable despite loud side conversations, a party in a neighboring room, and constant distractions from people walking by. We attribute this to the fact that the tactile channel is uncrowded compared to the audio channel. In a loud environment it is difficult to pick out audio communication from Skype. Visual distractions make it difficult to focus on the laptop monitor. The tactile sensation rarely stimulated in a teleconference, thus making the slightest vibration very noticeable.

We tried two different vibrating interfaces, a vibrating pen and a vibrating wrist patch. The wrist patch was unanimously rejected by the participants because 1) the double stick tape that connected the patch to the user's skin was either too sticky and removed arm hair or not sticky enough after a few uses and would fall off, 2) was tethered to the power supply and restricted movement to the point where the hand with the patch was essentially stationary, 3) vibrations on your wrist are not comfortable, and 4) worry that the patch might give the user an electrical shock. The pen had a practical use, writing, and although the pen was connected to the power supply, the user was not, and the range of motion was adequate enough to write anywhere on the drawing space.

We finally compared the tactile messaging conference to previous experiences with video conferencing and audio conferencing. These results are summarized in Appendix A.

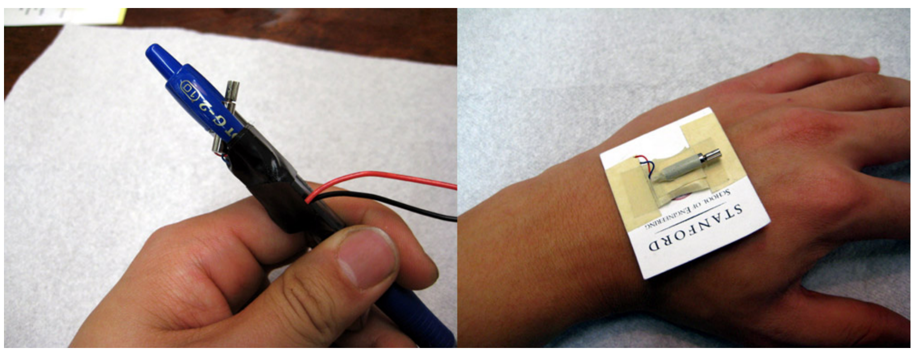

Figure 4.8: *The orientation of the two tactile messaging stations. (Note: the wires connecting the patch to power supply are not in this photo)*

The tactile messaging critical function prototype was a success in that it definitively answered all the critical questions we asked ourselves before testing.

5 Design Description

5.1 Vision

为用户提供的功能主要分两方面，远程操作者使用功能，现场机器人提供服务功能。

远程操作界面要集成一系列的应用功能。现场机器人要有足够多的自由度、传感器，确保提供服务的全面性、安全性。

5.2 机器人 CFP

移动机器人要能够充分实现操作者所需要的行动功能、音视频获取功能的一系列仿人类的功能。

- 摄像头视角：机器人的视觉是远程呈现的最核心部分，因此作为机器人的眼睛——摄像头的视角自然是需要十分关注的，单单一个具有较大视角的摄像头是不够的，我们需要摄像头有几乎 360 度的自由度，并且可以被用户操作旋转，以达到期望的视频捕捉效果。
- 机器人高度：移动底座与机器人“头部”的连接应该采用可以提供直线位移的推杆类结构，确保与现场的人员交互时能够达到比较好的效果。
- 机器人的角度：机器人面向的方向不应该由前进方向单一锁定，在高度可以调整的基础上，我们希望能够让机器人的面部能够在一定的控制下有充分的角度可调，甚至可以是全方位的周角。
- 交互界面：机器人的交互界面应该是由远程操作者来控制的，比如对话交流的时候，可以显示操作者的面部图像，使得现场人员感觉更加自然一些；在需要现场帮助的时候，例如操作者想去某个位置，但是由于对现场的陌生，无法立刻确认正确的站点，这时可以求助时，在屏幕上显示区位平面图，如果屏幕是可点击的触摸屏，现场人员直接就可以通过点击帮助远处的操作者选定位置。
- 传感器：机器人结构外围应该布置有数量足够的传感器，用以保证机器人安全，并且辅助行动。

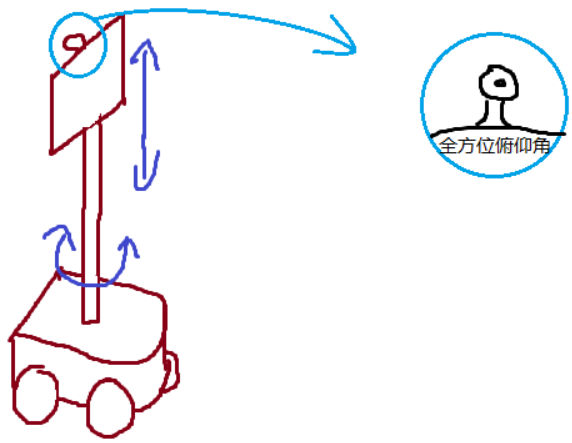

Figure 5.1: *A simple voltage dividing circuit provided 1.2V (HIGH) and 0.6V (LOW) buffered output voltages for the vibrating motor. Switches triggered the high and low voltages.*

5.3 操作网页 CFP

呈献给远程操作者的操作界面是提供远程参观、导航的一个至关重要的接口。该网页界面集合了本系统所有的远程服务功能。

5.3.1 数据接口

视频传输，音频传输，控制指令采集、传输，反馈信息传输。

视频传输的实时性是主要方面，在网络有延迟的情况下，可以适当牺牲视频品质，确保流畅、实时的特点。

音频传输与视频传输要保证一定的同步性。

控制指令的数据量较小，其主要的关注点在于可靠性，保证用户的每个指令都能可靠送达，并且不会由于网络的延迟而误导操作者进行误操作，比如当网络拥堵，用户发送了许多前进的指令，但是机器人接收时有丢包的现象，如果单单是累计确认指令的到达，由于 TCP 数据包本身的特点，会一并将累积的指令延迟后转入进程，从而使得机器人突然加速前进，造成事故。

另一个方面是控制指令的采集方式，比如敲击键盘，点击按钮，摆动摇杆等操作方式，这些操作依据用户喜好而定，用以增强用户体验。由于直接控制底层的前进、后退等指令对于某些用户过于“危险”，我们可以在界面上提供相应的平面图，并在平片图上设立相应的可点击的“站点”，用户通过点击这些站点，由已经存储的内置路线来操纵机器人相应的移动，并结合传感器来进行相应的避障行走甚至路线修正。

反馈信息是方便用户了解机器人的各项情况，用以辅助操作者进行相应处理。

(Text omitted for brevity)

5.3.2 权限设置

不同的用户通过登录来进入实用界面，但是用户是广泛的，我们无法直接管理每个用户的操作，故应该采取一定的权限设置，不同的使用者应该具有不同的使用权限。

比如我们完全信赖的人（我们的工作人员）能够直接操作机器人的各个基本功能，合法的用户不能直接控制机器人的底层移动，但是能够通过部分规定好的路线发出指令是机器人沿线行走，此种服务便会使用到之前陈述的可点击平面图的构想，同时，该类用户能够使用摄像头旋转、俯仰等没有涉及到机器人安全的器件的功能。而陌生的游客便只能通过接受视频等简单地信息来使用远程服务，而不能进行其他的使用操作，如此分级使得机器人的使用变得安全化、高效化。

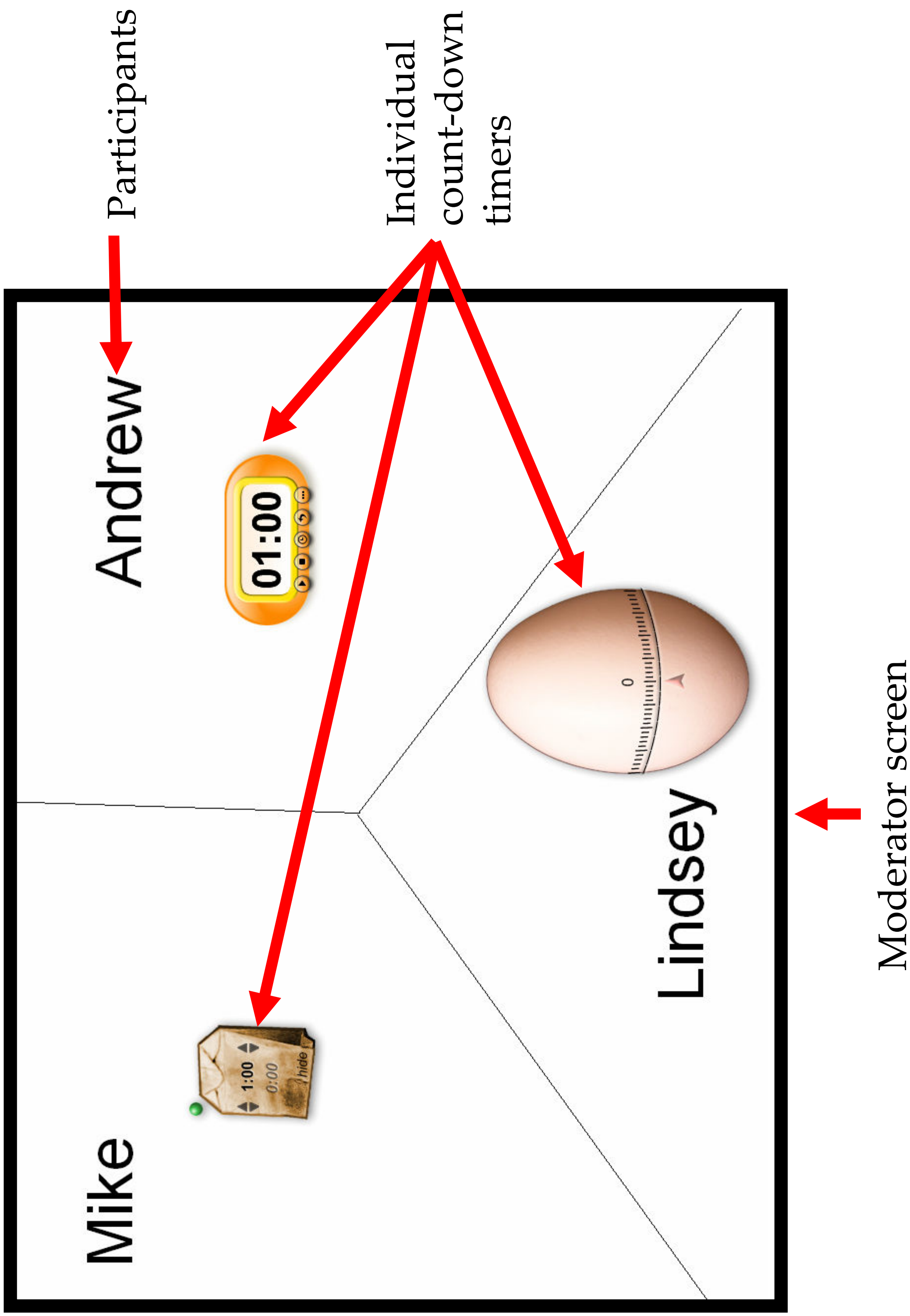

Figure 5.2: *View of moderator display*

6 Planning

6.1 Deliverables

Define briefly what is or will be delivered. A short table with some explanatory text could be used here. Your project plan should include the following non-negotiable items and any sub-tasks or intermediate items” that lead up to them:

- Paper Robot (Jan 11-13) – a mechatronic warm-up for winter
- Dark Horse prototype (Jan 25-27) – a 2nd CFP that probes the edge of the design space
- Travel Docs due (Feb 8)
- Funky Prototype (Feb 10) – a CFP where a potential avenue for the final product is developed
- Turning Point presentation (Feb 24)
- Functional Prototype Review (March 8-10) – your latest and greatest as Winter quarter draws to a close. It should give a clear indication of what to confidently expect in June.
- Winter Design Documents (March 17)

6.2 Milestones

When are various elements (e.g., rough prototypes, final prototypes) delivered? When are key tests conducted? These are the dates, times, and places where project progress is observable and/or demonstrated. Again, update with planned versus actual dates as the design progresses.

6.3 Project Time Line

Summarize the projected project time line if it is not already explicit in the project planning representations above.

Use any of the familiar project development representations including lists, Gantt Charts, Pert Charts (Figure 6.2), bubble diagrams, tables, etc. In addition, you will almost certainly need a list or table of items that says a bit more about the items and gives an idea who is going to do what.

6.4 Distributed Team Management

Explain how your distributed and interdisciplinary team will collaborate, communicate and keep itself on-track with respect to the afore-mentioned deliverables.

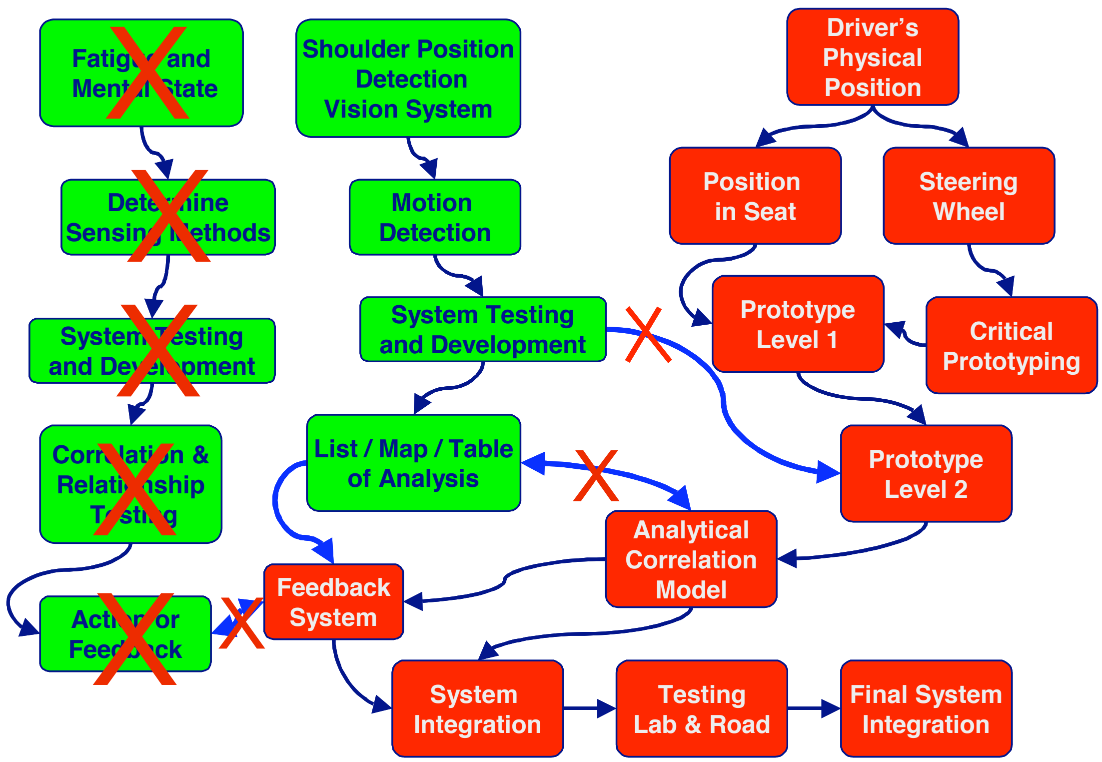

Figure 6.1: *In this example from [?], Stanford students collaborated with a group at TMIT, Japan. At the end of the Winter quarter it was decided to abandon one branch of the TMIT effort and to eliminate some of the tight coupling that was originally envisioned.*

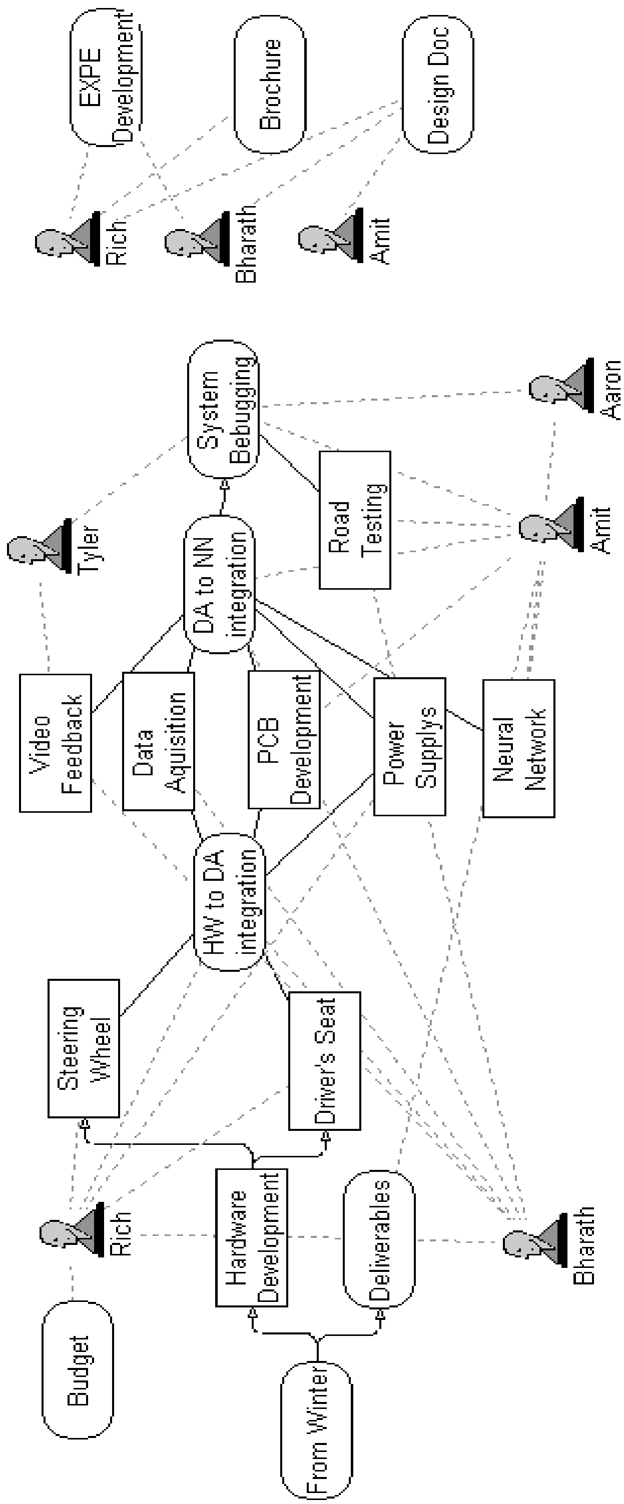

Figure 6.2: *An example of taking a large figure and having Latex rotate it 90 degrees to display it in landscape format as a full page figure.*

6.5 Project Budget

As with any serious proposal, you should include an estimated budget with some specifics about money that has been spent (Fall) and probably will be spent (Winter). Details on vendors can be put in the Appendix.

6.6 Reflections and Goals

This is the one section that you would not find in normal research or engineering proposal. But in the spirit that we're doing this in an academic setting, we want to be sure that we reflect on what we're learning and thinking and where we hope to go with it.

A part of this may include how your team functioned in the fall - explaining how and why your actual design process deviated from what you originally planned, if relevant. (Time lines and milestones often have the look of having been concocted the night before the report is due.)

7 Reources

Include lists of human, institutional and vendor resources here with contact information. This is not for direct citations, which go on the Bibliography.

Appendix A

Moderator Prototype Data

Adapted from Autodesk Fall 2007-08 [?].

	Length of Contribution (s)		
# Contributions	Andrew	Mike	Lindsey
Unmoderated			
1	40	2	15
2	50	22	25
3	30	1	3
4	8	13	19
5	68	5	21
6	5	2	9
7	6	21	17
8	17		5
9	14		12
10			6
2 min. moderated			
1	53	10	1
2	10	2	7
3	28	2	2
4	3	5	4
5	9	40	2
6	7	2	15
7	3	3	
8	39	25	
9	19	2	
10	10		
11	17		

	Length of Contribution (s)		
# Contribu	Andrew	Mike	Lindsey
1 min. moderated			
1	14	12	8
2	10	2	4
3	13	21	11
4	5	4	3
5	8	3	12
6	1	3	3
7	4	2	7
8	9	6	6
9	5	2	10
10	4	3	2
11	6	3	2
12	23	5	2
13	2	7	4
14	8	6	2
15	3		12
16	4		
17	5		

Figure A.1: *Length and number of contributions collected from recorded moderator test meetings*