OmniRoll

SDP18 | Team 21

PDR
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Team

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Problem Statement: Question and Answer

Problem: Virtual Reality (VR) currently lacks an immersive input for movement. Headsets and gaming systems require large, open spaces to physically roam in order to move in virtual space. Platforms used to track movement on the market currently are large, heavy, and prohibitively expensive.

Solution: Our goal is to create a low-cost, omnidirectional treadmill that allows for unlimited movement in a virtual space while keeping the user stationary. In addition, the treadmill should maintain immersion and allow for freedom of movement on a level surface. The entire system should be portable and easy to store in a home.

Problem Statement: What is OmniRoll?

What do we mean by "treadmill"?
Physical motion (legs moving, arms swinging) is not correlated to physical movement (distance traveled, speed achieved).

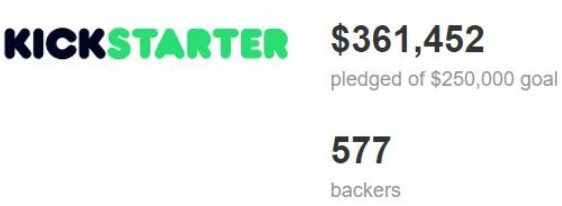
"Omnidirectional" in our case applies only in two dimensions.

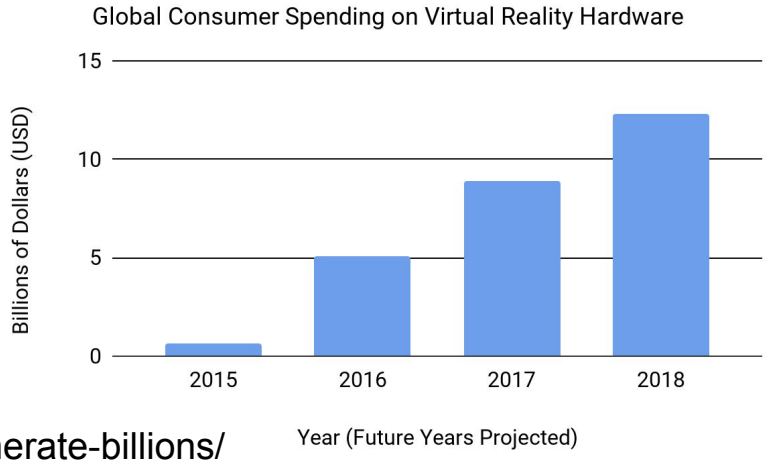
Problem Statement: I/O and Project Boundaries

- **Input**
  - Human walking motion
- **Output**
  - Physical movement data processed and ready to be sent to VR controller (computer)
- **Scope**
  - The OmniRoll system is a peripheral device for personal use
  - System converts human movement into data like any other controller (joystick, D-pad, keyboard, etc.)

Problem Statement: Why VR? Why OmniRoll?

- Increasing revenue in VR space
- Public interest exists
- Existing omnidirectional treadmills are too large, expensive, or otherwise ill suited for home use
- Has potential to improve VR experience dramatically





http://fortune.com/2016/01/05/virtual-reality-game-industry-to-generate-billions/
https://www.kickstarter.com/projects/1259519125/cyberith-virtualizer-immersive-virtual-reality-gam

System Specifications: Requirements

- Track user's movements on *x-y* plane
- Resists user from straying too far from center of platform
- Does not require user to drastically change stride, gait, or posture such that the user is uncomfortable
- Lag should not degrade immersion (must be <300ms)[1]
- Able to be activated/set up and deactivated/put away easily

[1] *Lag in Multiprocessor Virtual Reality,* Wloka 1995: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.51.8010&rep=rep1&type=pdf

Design Alternatives: Competitors

Cyberith Virtualizer

https://www.cyberith.com/

Description: Slippery surface with embedded sensors in base plate (optical sensors for foot location), support pillars (for height), and ring (for angle)

- **Cost:** $749 (Kickstarter cost)
- **Pros**:
  - Support system also measures crouching height
  - No need to purchase special shoes
  - Can be disassembled, little noise when in use
- **Cons**:
  - Cumbersome with 63" diameter, weighs 90 lbs
  - Awkward to use, surface is meant to slide on

Design Alternatives: Competitors

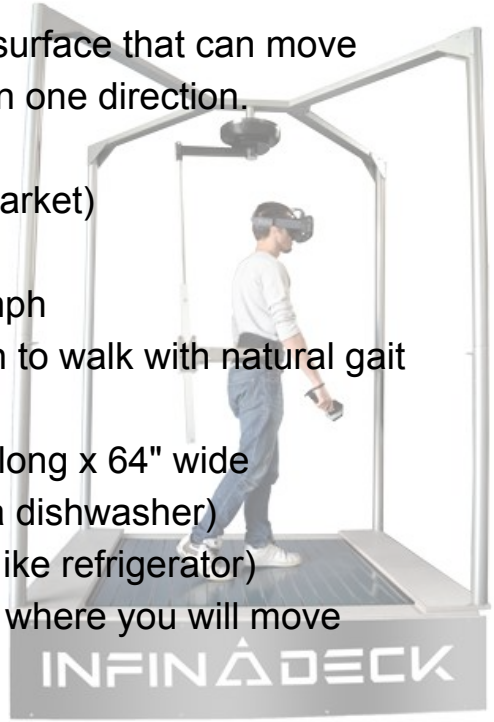
Infinadeck

[redacted]

http://www.infinadeck.com

Description: Large treadmill surface that can move 360 degrees, instead of only in one direction.

- **Cost: ~**$20,000 (not on the market)
- **Pros**:
  - Can move as fast as 6mph
  - Platform is large enough to walk with natural gait
- **Cons**:
  - Large and heavy at 68" long x 64" wide
  - Loud (70 decibels, like a dishwasher)
  - Uses 1200W of power (like refrigerator)
  - Uses harness to predict where you will move



Design Alternatives: Competitors

StriderVR

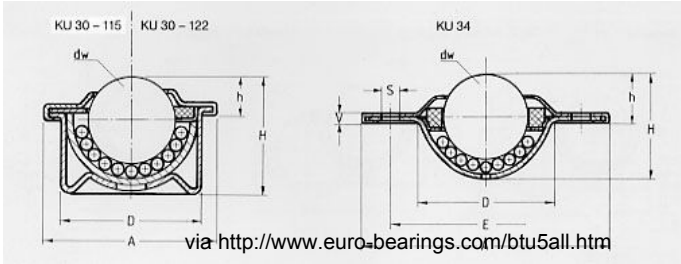
https://www.stridervr.com/

Description: Surface with bearings on top of a treadmill. Surface rotates to face Kinect at all times. Kinect senses location of feet, hands, and head, uses head to determine rotation

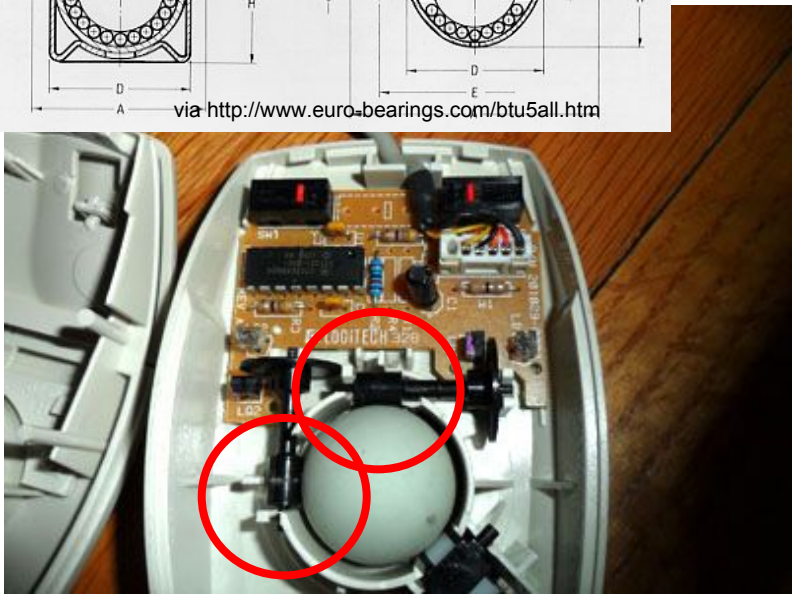
- **Cost:** ~$1,000 (estimate, not yet on the market)
- **Pros**:
  - Kinect can sense lifting foot / kicking ball
  - Takes up very little space, is compact
- **Cons**:
  - Rotation and body alignment is awkward
  - Hard to stop, must wait for it to slow down
  - Limited to walking; rotation slow/not natural
  - System has visible physical lag

Sensory System Options: Rollerball Mice

- Function:
  - Physical rollers break optical beam based on rotation of trackball
- Hardware:
  - Modify ball Xfer housings to accommodate X-Y sensors
  - Use aggregate of sensor inputs for translation into VR input
- Pros:
  - PS/2 mice are next to free
  - Includes hardware used to translate motion into serial data
- Cons:
  - Time consuming
  - Prone to dirt collection



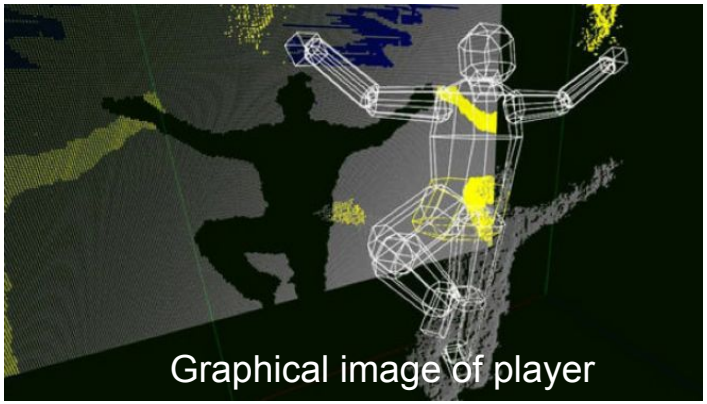
via http://www.euro-bearings.com/btu5all.htm



img src http://www.techdose.com/projects/Arcade-Trackball-Mouse-Hack/363/page1.html

Sensory System Options: Xbox Kinect

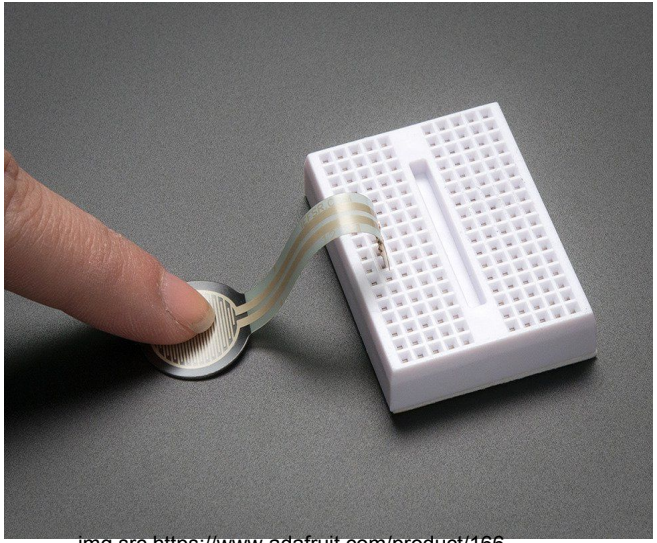
- Function:
  - Uses AI machine-learning algorithm to collect and map visual data to skeletal models representative of human beings based on size, clothing, etc.
- Hardware:
  - **RGB color VGA video camera**- detects body-type and facial features, (640x480 resolution at 30fps)
  - **Depth sensor**- contains an infrared projector and a monochrome CMOS sensor to capture 3D video data and measures the distance of the player's body
- Pros:
  - Inexpensive depth-sensitive camera, can also track motion of extremities
- Cons:
  - Would need at least 2 kinect sensors to track 360 degree movement, may be difficult to process images



https://www.jameco.com/Jameco/workshop/Howitworks/xboxkinect.html

Sensory System Options: Node Array/FSRs

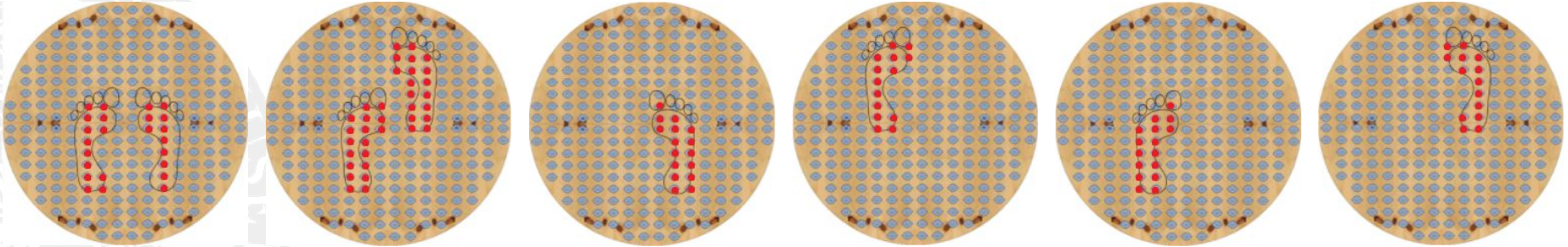
- Function:
  - **Force Sensitive Resistors (FSRs)** change their resistance based on applied pressure
  - FSRs are arranged underneath ball transfers as array of "switches" in on/off state
  - Switch is triggered by pressure (i.e. foot)
- Hardware:
  - Resistive analog output → determine on/off threshold
    - Output of sensor converted to digital signal
  - Sensors not placed under *every* ball transfer
- Pros:
  - Lightweight
  - Digitized data is much easier to process than video or other resistive data
- Cons:
  - Individual FSRs can be expensive



img src https://www.adafruit.com/product/166

Sensory System Options: Node Array/FSRs

What it might look like to take a step: **(e.g. a few steps in the forward direction)**



Frame 1: Standing still. No change in movement detected.

Frame 2: Step forward with right foot.

Frame 3: Right foot rolls back to starting position.

Frame 4: Step forward with left foot, other foot lifts off platform.

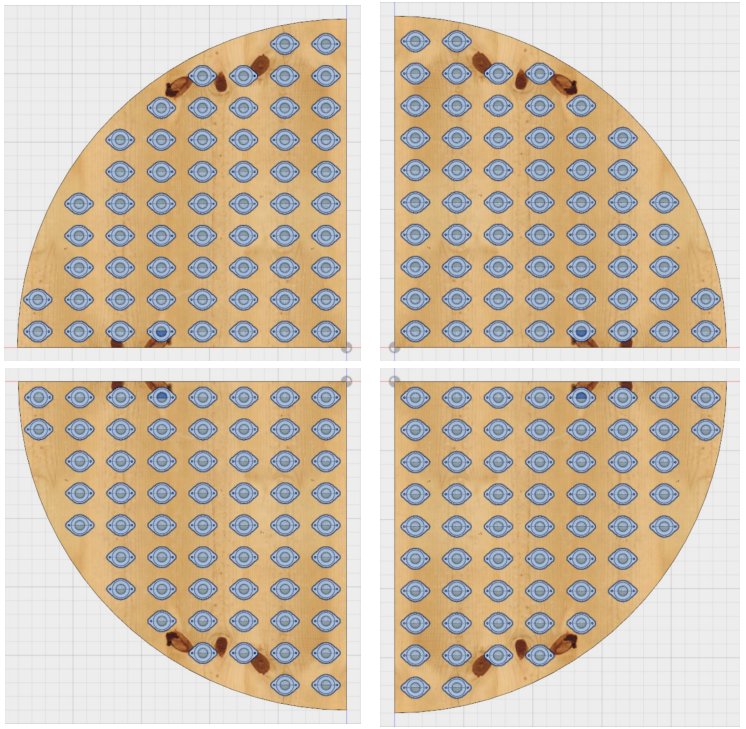
Frame 5: Left foot rolls back to starting position.

Frame 6: Step forward with right foot, other foot lifts off platform.

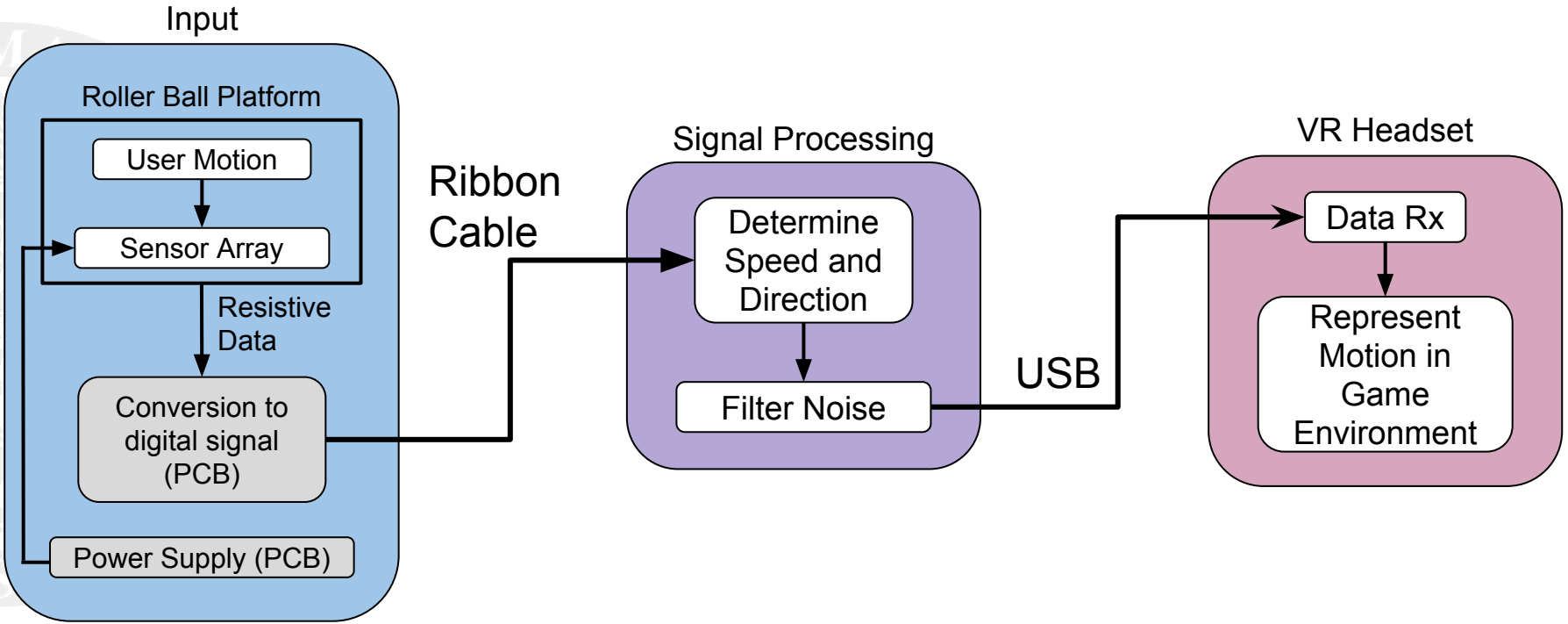
Time

Preliminary Design

- Four lightweight interlocking pieces with embedded pressure sensors and ball bearing transfers
- Assemble to create 4' diameter platform
- Platform sensor outputs feed into PCB (ADC), then microcontroller
- Microcontroller computes digital signal for computer to use as input into game engine



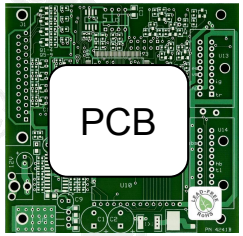
Block Diagram



Block Diagram: Implementation

Ball Bearings with FSRs

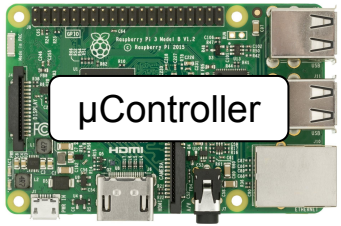
OmniRoll Platform



FSR sensor output

Power source for sensors

Ribbon cable supplies sensor data in parallel

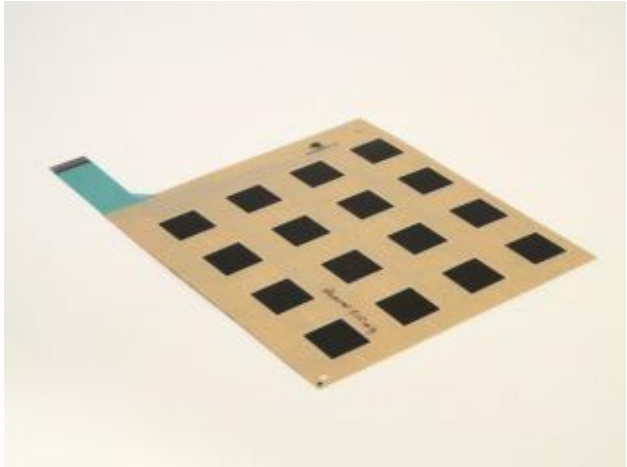


Signal processing to determine speed and direction from FSR data
Filter noise if necessary

Output is sent through USB to VR console

MDR Deliverables

- **Demonstration of physical device**
  - Test sensors on small area of bearings
  - Create surface large enough to walk on
- **Demonstration of raw output from platform**
  - Create algorithms translating mock sensor data into digital input for game engine (joystick)



img src http://www.sensitronics.com/products-discrete-fsr-arrays.php

Preliminary Prototype Budget

• Ball Bearings	(240) 5/8"	$250 estimate
• Fasteners	(480) 6M screws	$25 estimate
• Plywood	(1) 1/4" x 4' X 4'	$10 estimate
• Force Sensors	(80)	$100 estimate
• Microcontroller	(1)	$40 estimate
• PCB Manufacturing	(1)	$70 estimate
• Power Supply	(1)	$5 estimate
▪ TOTAL:		$500

Questions?