ARK

SDP18 | Team 21

MDR
12/07/2017

Team

Matteo Bolognese, EE
Device Design, Assembly
PCB Design, & Power

Chad Klinefelter, CSE
User Interface & Backend
App Development

Jackie Lagasse, CSE
Augmented Reality
App Development

Ethan Miller, EE
Device Communication
Sensor Interfacing

PDR Feedback / Problem Statement

- Our previous design (OmniRoll) could not find a niche to separate from other low-cost omnidirectional treadmills made for home use.
- Instead, decided to pivot focus to Augmented Reality (AR).
- **Problem Statement:**
  - AR users are unable to incorporate extremities into a game unless their device camera can directly face them.
  - There are no inertial sensing products for extremity tracking that can be used in AR gaming.

Augmented Reality (AR)

What is Augmented Reality?

- Computer responds to physical environment through object recognition or computer vision
- User requires view of physical world through goggles or screen
- World is augmented through overlaid visuals, sounds
- Distinct from Virtual Reality (VR)

http://www.solidapps.co.uk/blog/2013/02/now-available-edrawings-for-ios-with-augmented-reality/

Background Information

ARK (Augmented Reality Kick) is an augmented reality gaming device with an accompanying Android App.

- Soccer is played by roughly 265 million people worldwide (FIFA survey).
- AR is capable of running on most new smart phones (iPhone, Galaxy, Pixel, etc.) with APIs directly from OS developers.
- Why a separate foot attachment?
  - To overcome current limitations in AR gaming. In particular, being unable to incorporate extremities into the game unless the phone camera directly faces the extremities.
  - Sensor on foot can transmit data to phone, where it can then be acted upon.

Our Vision

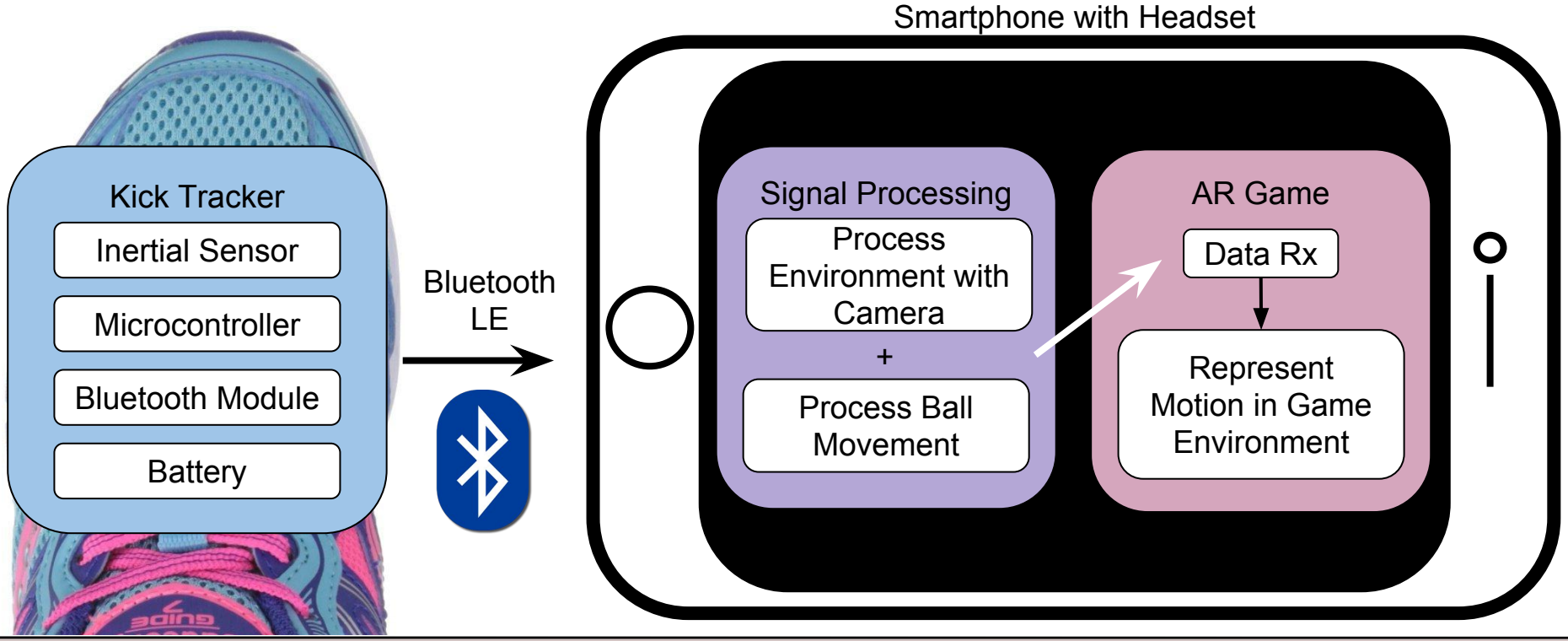
On demo day we plan to present the following:

- Bring user to an open space
- User wears headset and kick tracker
- Start ARK app on phone
- App displays virtual soccer ball and goal
- User kicks foot, observes movement of soccer ball

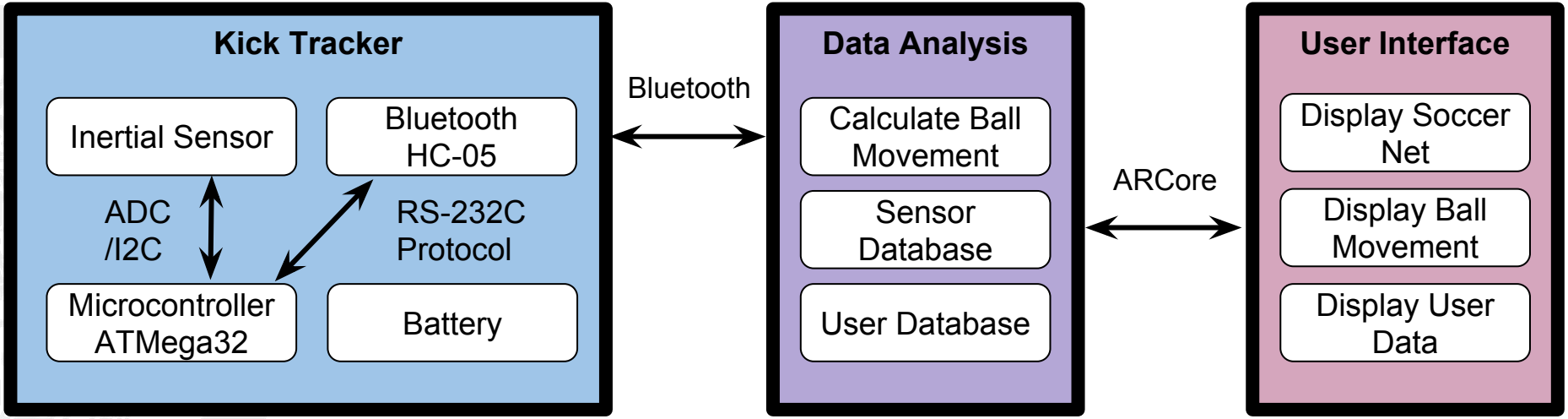
System Requirements

- App must have clean and user friendly interface, must create virtual soccer goal and ball, must allow ball to move when kicked
- App must properly determine user’s kick speed, direction
- Ball must move realistically in relation to user's movement (should miss if kicked in wrong location, consistent speed)
- System delay must be low enough to retain immersion (satisfactory at less than 300ms, ideally less than 100ms)
- Kick tracker must be lightweight, enclosed, and easy to calibrate
- The device must be rechargeable, last for a few hours of continuous use on one charge, and be as inexpensive as possible

Concept Diagram



Block Diagram



All components in foot attachment will be connected together in PCB.

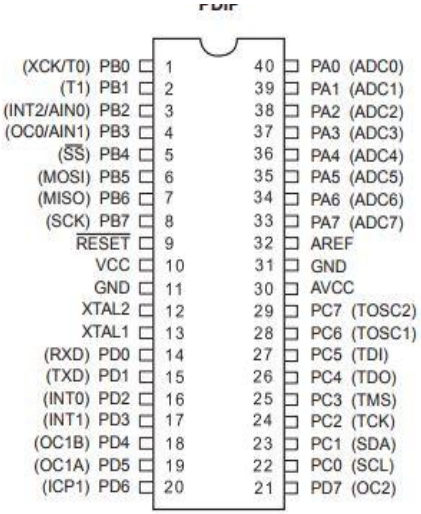
Battery will be rechargeable.

User data consists of user's score count, ie how many goals earned in this play through.

Microcontroller

Atmel AVR ATMega32

- Have experience from using in ECE 353, easily obtain programming hardware and AVR Studio
- Has several communication interfaces including
  - USART for Bluetooth module
  - ADC and I2C for sensor data
- Clock rate up to 16MHz means higher data throughput
- Inexpensive, about $6 each



http://www.atmel.com/images/doc2503.pdf

Bluetooth Module

HC-05 Wireless Bluetooth Serial Transceiver

- Contains USART module to communicate with ATMega32 processor
- Uses standard Bluetooth functionality
- One line BT Tx to uProc Rx, another line uProc Tx to BT Rx
- Inexpensive, about $9 each

https://arduino-elektronika.eu/12250-thickbox/hc-05-masterslave-bluetooth-module.jpg

Sensors

Bosch BMI160 Shuttle Board

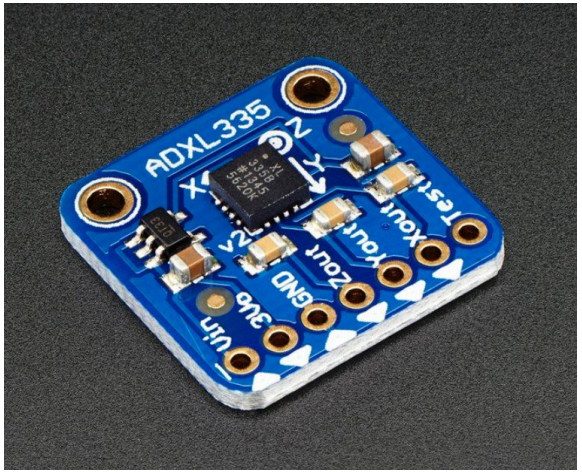
- Includes BMI160 Accelerometer / Gyroscope and BMI150 Magnetometer sensors
- High quality, currently used in high end mobile phones for augmented reality applications
- Can use SPI or I2C communication
- Many included features such as step counter, power management, timestamping data, capable of integrating external sensor data

http://www.mouser.com/ds/2/783/BMI160_Shuttleboardflyer_BST_20170112-1221218.pdf

Sensors

Adafruit ADXL335

- 5V Triple-axis Analog Accelerometer
- Small, thin, low-power, temperature stability
- On-board 3.3V regulator
- Minimum full scale range of ±3g
  - -3g is at 0V output
  - 0g is at 1.65V output (half of 3.3V)
  - 3g is at 3.3V output
- Can measure dynamic acceleration
  - Motion, shock, and vibration



https://www.adafruit.com/product/163

Battery

- Strongest option: LiPo 18650 cell (~$5 per)
  - Single cell outputs 3.7V, nominal capacity 2600mAh (dependent on manufacturer)
  - 44g weight, slim packaging useful for placement on leg
  - Will be in enclosure to protect cell from damage
- Cheaper alternative is NiMH cell, safer to store, however lower voltage (1.2V) would require more cells to power devices

https://www.orbtronic.com/vtc5-18650-battery-imr-2600mah-us18650vtc5

Power System Analysis

Device	Average Current
ATMega32L @8MHz, 3.3V, no PicoPower	~6 mA
HC-05 Bluetooth (no power savings)	~8 mA
Bosch BMI160 (no low power)	~ 1.1 mA
Adafruit ADXL335, 3.3V	~0.45 mA

- Assuming the highest power consuming sensor, average current will be roughly 15.1 ma.
- Assuming a 2500mAh cell,

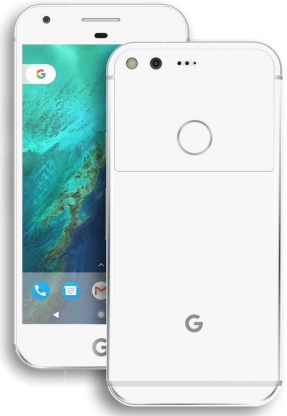
2500mAh / 15 mA = **166.7 h of battery life per charge**

- Energy storage is not critical aspect of design

https://www.orbtronic.com/vtc5-18650-battery-imr-2600mah-us18650vtc5

Application Development

- App being developed in Android Studio
- Data primarily transferred over BT sockets (similar concept to TCP sockets)
- Augmented Reality code will be based off the free ARCore API from Google
- Will be using Google Pixel XL and / or Samsung S8 phones, both compatible with ARCore API



https://goo.gl/images/RSfR4s https://goo.gl/images/Dm43S7

Headset

Starlight SL-001 VR Headset

- Compatible with AR and VR applications
- Expands to fit various phone sizes, can fit both phones we are interested in using
- Lenses are adjustable for different eye distance and optical focus
- Inexpensive, $12-$25 per pair

http://www.starlightvr.com/

Budget & Cost Analysis

Items to Date:	#	Total Cost
Ball Bearings	30	$42
ATMega32	2	$15 (with shipping)
HC-05 Bluetooth	2	$18
BMI160 Board	2	$79 (with shipping)
Adafruit ADXL335	1	$15
Battery	2	$11
PCB Manufacture	1	$20
Starlight Headset	1	$12
Total:		**$212**

Production Cost Per Unit

Items per Device	#	Bulk Cost
ATMega32	1	$4.46
HC-05 Bluetooth	1	$4.33
Inertial Sensor	1	$20-$40
Battery	1	$2.42
PCB Manufacture	1	$1.00
Starlight Headset	1	$12
Total:		**$44.21-64.21**

Even cheaper if user has their own headset!

MDR Deliverables

Deliverable	Status	Team Member
Select and purchase inertial sensor, microcontroller, Bluetooth module, and battery	Completed (except battery)	Matteo & Ethan
Assemble purchased components together	Completed	Matteo, Jackie, Chad, & Ethan
Send data from inertial sensors to phone over Bluetooth	Completed	Matteo, Jackie, Chad, & Ethan
Display data from sensors in Android App	Completed	Jackie & Chad

MDR Demo

Proposed CDR Deliverables

App

- Augmented reality must be implemented to show soccer goal and soccer ball **(Jackie)**
- Backend of app must store sensor data, model data to analyze foot movement **(Chad & Ethan)**

Device

- Kick accuracy measurement **(Ethan)**
- Design PCB, send for fabrication **(Matteo)**
- Design foot mount structure and enclosure **(Matteo)**

Team Member	Color Code
Matteo	
Jackie	
Chad	
Ethan	

Gantt Chart

		Start	Bench			Bench	CDR		Break	Bench			FDR	
Assignee	**Task**	**Jan. 22**	**Jan. 29**	**Feb. 5**	**Feb. 12**	**Feb. 19**	**Feb. 26**	**Mar. 5**	**Mar. 12**	**Mar. 19**	**Mar. 26**	**Apr. 2**	**Apr. 9**	**Apr. 16**
Matteo	Design, Order PCB													
Jackie	Develop App, Soccer Goal													
Chad	Develop App, Backend													
Ethan	Integrate Sensor w/Backend													
Matteo	Design Foot Mount, 3D Print													
Jackie	Develop App, Soccer Ball													
Chad	Develop App, UI													
Ethan	Assess Accuracy of App													
Matteo	Assemble PCB, Foot Mount													
Jackie	Develop App, Motion Accuracy													
Chad	Develop App, Motion Accuracy													
Matteo	Assess Accuracy of App													
All	Final Integration of System													

Thank You!

Questions?

Bulk Pricing References

ATMega32
https://www.mouser.com/ProductDetail/Microchip-Technology-Atmel/ATmega32-16PU/?qs=aqrrBurbvGdpkmgj7RWmsQ%3D%3D

HC-05
https://www.dhgate.com/product/hc05-jy-mcu-anti-reverse-integrated-bluetooth/401037278.html#s1-1-1b;srp|2321066803

LiPo Battery
https://www.dhgate.com/product/hot-vtc5-18650-us18650-3-7v-30a-2600mah-vtc5/402133835.html#s1-0-1b;srp|0029339464

PCB
https://www.pcbcart.com/quote