BME Design-Spring 2024 - NOLAN BLOMWILLIS
Complete Notebook

PDF Version generated by

James Waldenberger

on

May 01, 2024 @10:27 PM CDT

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Team contact Information

James Waldenberger - May 01, 2024, 10:16 PM CDT

Last Name	First Name	Role	E-mail	Phone	Office Room/Building
Settell	Megan	Advisor	settell@wisc.edu	N/A	N/A
Gold	Robert	Client	bob.gld@gmail.com	N/A	N/A
BlomWillis	Nolan	Leader	blomwillis@wisc.edu	920-287-1468	N/A
Kafar	Kaden	Communicator	kafar@wisc.edu	262-492-2287	N/A
Parsons	Jacob	BSAC	jcparsons@wisc.edu	262-232-5907	N/A
Waldenberger	James	BWIG	jwaldenberge@wisc.edu	262-229-1557	N/A

Project description

James Waldenberger - May 01, 2024, 10:16 PM CDT

Course Number:

BME 301

Project Name:

Preventing Weight Lifting Injuries By Barbell Modifications

Short Name:

Weight Lifting Injuries

Project description/problem statement:

Over one million weightlifters each year experience weightlifting injuries that put them in the emergency room. Of these one million, 18-46% are reported to be caused by bench pressing a barbell. Our team's task is to create a pitch-able system that increases safety for lifting, specifically bench pressing.

About the client:

Rob Gold is a pharmacist out of Evansville, Indiana that works with multiple colleges to try and realize his ideas for inventions in a variety of different disciplines.

2024/01/29 1st Client Meeting

Jacob Parsons - Jan 29, 2024, 6:37 PM CST

Title: 1st Client Meeting

Date: 1/29/24

Content by: Jacob Parsons

Present: Whole Team

Goals: To gain a basic understanding of the project.

Content:

- Bob is a pharmacist and works with doctors, does inventions in spare time - Evansville, Indiana

- 1 million people injure themselves every year with lifting (lots of shoulder injuries while benching)

- How can we make this safer (the barbell)?
- How do we show the user that you are uneven? VISUALIZE

- EMT sensor used to analyze the stress undergone by muscle

- Collect data on speed, level, reps, etc - can we see the reps on the bar

- What is something that has never been done before?

- Lots of people use accelerometers, but that's been done - do something new

- Use of radar?

- Don't want anything on the wrists, focus on barbell modification

- Wants to count reps and measure balance

- Would be really cool to measure the muscle - not necessary.

1. How can you make lifting safer?

2. What kind of stress are you putting on the muscle?

- How can you combine those last two questions?

Conclusion:

- Do research on other current products out there - try to find something that is new

- Read up on journals with people who did research on weightlifting injuries

- Main interest of client is to observe the levelness of the product - ideally want to find way to track other aspects of the rep

- How can you make weightlifting safer - what is a tell for injury?

2024/2/13 2nd Client Meeting

Jacob Parsons - Feb 16, 2024, 12:18 PM CST

Title: Client Meeting

Date: 2/13/2024

Content by: James Waldenberger

Present: Kaden Kafar, Jacob Parsons

Goals: Confer with Bob about our ideas for the design matrix and get his opinion on the types of designs that we want to look at moving forward, especially with regard to what technology the design will be using, as Bob made a point to say that it should be something new.

Content:

- Still wants RADAR application in the barbell modification device, possibly in conjunction with something on the floor that communicates with the bar
- Sleeve that fits over the bar?
- Choose a technology that's never been done, shows uneven-ness, counts reps
- What are cars using to locate objects? might want to look into
- Contact an engineer at a place that makes sensors, get their input
- Wants us to look deeper into every alternative, worry less about the final project
- Never been used + probably would work + relatively inexpensive = DO IT!
- Why aren't these products that we're researching in Wal-Mart? Because they aren't imaginative
- Show user "good lift" or "bad lift"
- In case of uneven or unsmooth lift, inform user that weight should not be increased
- Contact a kinesiologist/strength coach/sports science person and get info regarding a bad lift
- Liked our idea of VR or augmented reality to have an interface during the lift
- Display on the bar that shows you all the info of the lift (phone attachment, other display screen)
- Something that can work with a standard barbell rather than a whole new barbell

Conclusions/action items:

More research on sensors or ways to track the lift is in order. The design matrix will hopefully help us compare and contrast these technologies against one another to come to a "final" decision on what we want to use.

2024/2/2 Advisor Meeting

KADEN KAFAR - Feb 02, 2024, 1:14 PM CST

Title: 2024/02/02 Advisor Meeting

Date: 02/02/2024

Content by: Kaden Kafar

Present: Kaden, Nolan, James

Goals: Take notes of meeting with advisor.

Content:

-Keep track of weekly progress report due every Thursday.

-Notebook check every Friday due at 2 pm.

-PDS due next Thursday.

-Focus and find a concise goal of the project.

Conclusions/action items:

-Conduct team meeting to discuss PDS and main objectives.

2024/02/09 Advisor Meeting

NOLAN BLOMWILLIS - Feb 09, 2024, 1:06 PM CST

Title: Advisor Meeting

Date: 2/9/24

Content by: Nolan BlomWillis

Present: Whole team, Advisor, TA

Goals: Discuss project

Content:

-Discuss progress made

-Discuss the direction we are taking the project

-Told advisor there is a meeting in place for the client to meet before

-TA has good comp sci experience if help is needed

-Showed TA regarding accelerometer

-Look at WARF to understand the patents better

-Look toward home gym modifications

-Next step is design matrix

Conclusions/action items:

-Work on design matrix

-Fix up resumes and cover letters

2024/02/16 Advisor Meeting 3

NOLAN BLOMWILLIS - Feb 16, 2024, 1:09 PM CST

Title: Advisor Meeting

Date: 2/16/24

Content by: Nolan BlomWillis

Present: Whole team, Advisor

Goals: Discuss project

Content:

Talk about Design Matrix with Megan

- At home gym market towards

- The newer crowd to lifting is more susceptible to injuries

- Spine Lab has some motion analysis at UW, look into clinical spine labs

-Megan will reach out to Spine lab

-Reach out to biomaterials professor about motion detection(Kaden)

-360 degree lidar scanners

Conclusions/action items:

-Work on minor testing for ultrasonic sensor

2024/02/23 Advisor Meeting

NOLAN BLOMWILLIS - Feb 23, 2024, 1:00 PM CST

Title: Advisor Meeting

Date: 2/23/24

Content by: Nolan BlomWillis

Present: Full team, TA, Advisor

Goals: Discuss progress and future goals

Content:

-Explained what we each researched this week

-Kaden explained the work he did with the ultrasonic sensor and code for it.

-Kaden explaining the proof of concept that the ultrasonic sensor was used for

-Then showed advisor what options are out there for ultrasonic sensors

-Showed preliminary presentation progress

-Discussed deadlines

Conclusions/action items:

Finish up "Rough Draft" prelim presentation by Wednesday, figure out what to order.

2024/02/02 Team Meeting Design Ideas

NOLAN BLOMWILLIS - Feb 02, 2024, 1:33 PM CST

Title: Team meeting to determine direction of where to go

Date: 2/2/2024

Content by: Nolan BlomWillis

Present: James W, Kaden K, Nolan B

Goals: Come up with a direction for project

Content:

-Biomechanics motion sensors could be hooked up to body to detect motion and arm angles

-Looking to go down the route of designing a system that helps the lifter know their technique is not correct

-Radar idea does not seem feasible or "pitch-able"

-Leveling seems to be well versed by now with patents

-Looking down the rout of "sell-ability" and improving safety maybe not as much the balance and leveling side of weightlifting

-We want to create a pitch-able system that improves safety for weightlifting specifically bench pressing, this is our direction we are going.

Conclusions/action items:

Work on PDS for the next week with this direction in mind

2024/02/09 Team Meeting Design Matrix

NOLAN BLOMWILLIS - Feb 09, 2024, 1:42 PM CST

Title: Design Matrix Meeting

Date: 02/09/24

Content by: Nolan BlomWillis

Present: full team

Goals: Create 3-4 designs and pick our categories for design matrix

Content:

- How do we define safety vs accuracy? Safety is what we are trying to solve but also making sure the device is mot dangerous

-Picking our categories based on client requirements

-Debating how to add live feedback requirement as a category

-Two design matrix one for where the device goes and then the measuring of balance

-Ordered the design matrix categories.

Conclusion/Action Items:

Get grading the designs. James will do drawings and the rest of the team will grade and explain each section.

2024/02/21 DEI in Design

NOLAN BLOMWILLIS - Feb 21, 2024, 1:45 PM CST

Title: DEI in Design

Date: 2/21/24

Content by: Nolan BlomWillis

Present: Jacob, Kaden, James, Nolan

Goals: Look at our design

Content:

Component to be improved: User interface should be understood by anyone who is looking to use our device whether they are a beginner in the field or an expert. Also if they don't have background in electronics or are not technologically advanced.

Principle addressed: Equitable Use/Simple and Intuitive Use/Perceptible Information

How to make this improvement: Make an interface that is not too complex and keep these three principles in mind when fabricating the device's interface.

Conclusions/action items:

Refer back to the three principles when in the fabrication stage.

2024/05/01 Materials and Expenses Table

Jacob Parsons - May 01, 2024, 8:19 PM CDT

Title: Materials and Expenses Table

Date: 5/1/24

Content by: James Waldenberger

Present: N/A

Goals: Compile a list of expenses that the team had throughout the course of the semester

Content:

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	QTY	Cost Each	Total	Link
Ultrasonic Sensors										
CUI Ultrasonic	Ultrasonic Sensor	CUI	N/A	CUI Devices	N/A	3/14	2	$6.70	$22.93	url
Max Ultrasonic	Ultrasonic Sensor	Max Sonar	N/A	MaxBotix	N/A	3/14	2	$29.95	$68.95	url
Other										
Power Supply	Battery used to supply power to screen attachment	QTshine	N/A	Amazon	N/A	4/14	1	$29.95	$29.95	url
Screen	Display attached to center of barbell	SparkFun	N/A	Dr. Nimunkar	N/A	4/14	1	$0	$0	url
Velcro	Used to attach housing blocks to barbell	Foxgor	N/A	Amazon	N/A	4/14	1	$9.99	$9.99	url
Wire Components	Extra electrical components to attach everything	N/A	N/A	Makerspace	N/A	4/14	1	$0	$0	N/A
Housing Block	3D Printed Housing chamber	N/A	N/A	Makerspace	N/A	4/19	1	$18.28	$18.28	N/A
Raspberry Pi Pico W	Used to gather data from ultrasonic sensors and wirelessly transmit it to the main terminal	Generic	B0B72GV3K3	Amazon	N/A	4/14	3	$27.99	$27.99	url
Battery Housing	Holds 3 AA batteries to power the Pico W microcontrollers	LampVPath	B07T7MTRZX	Amazon	N/A	4/14	3	$6.99	$6.99	url
AA Batteries	AA Batteries to power Pico Ws	Duracell	B002UXRXEG	Amazon	N/A	4/14	10	$14.32	$14.32	url
								TOTAL:	$199.40	

Conclusions/action items:

Update table as needed when more items are purchased.

2024/02/18 Ultrasonic Sensor

KADEN KAFAR - Feb 18, 2024, 3:29 PM CST

Title: Ultrasonic Sensor

Date: 2/18/2024

Content by: Kaden Kafar

Present: Kaden Kafar

Goals: Create a basic system using an arduino and ultrasonic sensor to measure position, velocity, acceleration.

Content:

code:

```
/*

 * created by Rui Santos, https://randomnerdtutorials.com

 *

 * Complete Guide for Ultrasonic Sensor HC-SR04

 *

    Ultrasonic sensor Pins:

        VCC: +5VDC

        Trig : Trigger (INPUT) - Pin11

        Echo: Echo (OUTPUT) - Pin 12

        GND: GND

 */



int trigPin = 11;    // Trigger

int echoPin = 12;    // Echo

double m, inches, duration1, duration2;
```

```
void setup() {

  //Serial Port begin

  Serial.begin (9600);

  //Define inputs and outputs

  pinMode(trigPin, OUTPUT);

  pinMode(echoPin, INPUT);

}



void loop() {

  // The sensor is triggered by a HIGH pulse of 10 or more microseconds.

  long double t1 = millis();

  // Give a short LOW pulse beforehand to ensure a clean HIGH pulse:

  digitalWrite(trigPin, LOW);

  delayMicroseconds(5);

  digitalWrite(trigPin, HIGH);

  delayMicroseconds(10);

  digitalWrite(trigPin, LOW);



  // Read the signal from the sensor: a HIGH pulse whose
```

```
// duration is the time (in microseconds) from the sending

// of the ping to the reception of its echo off of an object.

pinMode(echoPin, INPUT);

duration1 = pulseIn(echoPin, HIGH);



// Convert the time into a distance

double m1 = (duration1/2) / 2910;     // Divide by 29.1 or multiply by 0.0343

double inches1 = (duration1/2) / 74;   // Divide by 74 or multiply by 0.0135

delay(500);

// Give a short LOW pulse beforehand to ensure a clean HIGH pulse:

digitalWrite(trigPin, LOW);

delayMicroseconds(5);

digitalWrite(trigPin, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin, LOW);



// Read the signal from the sensor: a HIGH pulse whose

// duration is the time (in microseconds) from the sending

// of the ping to the reception of its echo off of an object.

pinMode(echoPin, INPUT);
```

```
duration2 = pulseIn(echoPin, HIGH);



// Convert the time into a distance

double m2 = (duration2/2) / 2910;     // Divide by 29.1 or multiply by 0.0343

double inches2 = (duration2/2) / 74;   // Divide by 74 or multiply by 0.0135

long double t2 = millis();

double time = (t2 -t1) /1000;

m = m1-m2;

inches = inches2 - inches1;

double vel_m1 = m / time;

double vel_inch1 = inches / time;


// The sensor is triggered by a HIGH pulse of 10 or more microseconds.

long double t3 = millis();

// Give a short LOW pulse beforehand to ensure a clean HIGH pulse:

digitalWrite(trigPin, LOW);

delayMicroseconds(5);

digitalWrite(trigPin, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin, LOW);
```

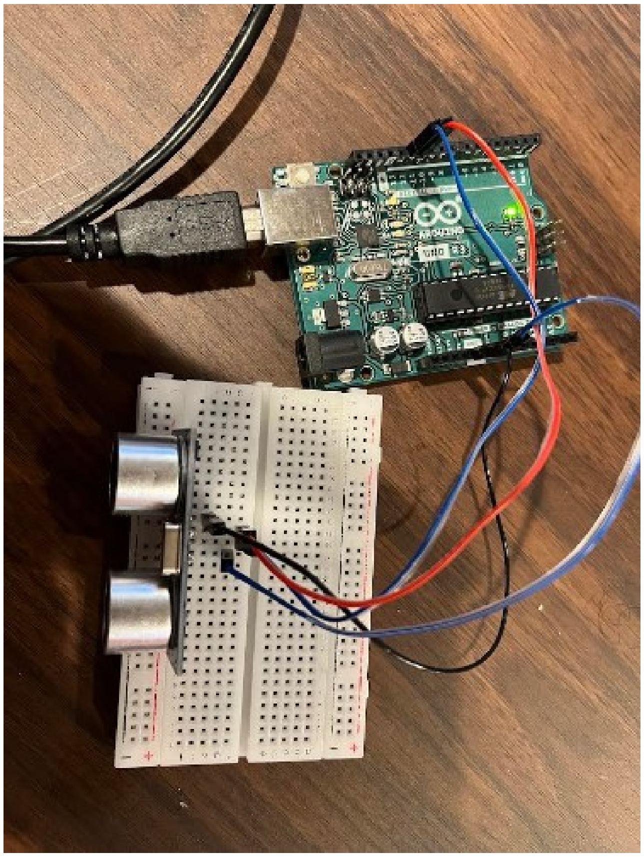
```
// Read the signal from the sensor: a HIGH pulse whose

// duration is the time (in microseconds) from the sending

// of the ping to the reception of its echo off of an object.

pinMode(echoPin, INPUT);

double duration3 = pulseIn(echoPin, HIGH);



// Convert the time into a distance

double m3 = (duration3/2) / 2910;     // Divide by 29.1 or multiply by 0.0343

double inches3 = (duration3/2) / 74;   // Divide by 74 or multiply by 0.0135

delay(500);

// Give a short LOW pulse beforehand to ensure a clean HIGH pulse:

digitalWrite(trigPin, LOW);

delayMicroseconds(5);

digitalWrite(trigPin, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin, LOW);



// Read the signal from the sensor: a HIGH pulse whose

// duration is the time (in microseconds) from the sending

// of the ping to the reception of its echo off of an object.
```

```
pinMode(echoPin, INPUT);

double duration4 = pulseIn(echoPin, HIGH);



// Convert the time into a distance

double m4 = (duration4/2) / 2910;     // Divide by 29.1 or multiply by 0.0343

double inches4 = (duration4/2) / 74;   // Divide by 74 or multiply by 0.0135

long double t4 = millis();

double times = (t4 -t3) /1000;

double ms = m3-m4;

double inchess = inches4 - inches3;

double vel_m2 = ms / times;

double vel_inch2 = inchess / times;

double time2 = (t4 - t1) / 1000;

double acc = (vel_inch2 -vel_inch1) / (time2);

Serial.print(inches1);

Serial.print("in1, ");

Serial.print(inches2);

Serial.print("in2,  ");

Serial.print(vel_inch1);

Serial.print("vel1,  ");
```

```
  Serial.print(vel_inch2);

  Serial.print("vel2,  ");

  Serial.print(acc);

  Serial.print("acc.");

  Serial.println();



  delay(500);

}
```

This records and prints out velocities and accelerations.

```
10.38in1, 10.20in2,  -0.35vel1,  0.32vel2,  0.65acc.
10.70in1, 10.70in2,  0.00vel1,  -0.69vel2,  -0.68acc.
10.18in1, 10.54in2,  0.71vel1,  -0.01vel2,  -0.71acc.
10.53in1, 10.20in2,  -0.65vel1,  0.67vel2,  1.30acc.
10.66in1, 10.47in2,  -0.37vel1,  1.13vel2,  1.48acc.
```



Conclusions/action items:

Find ways to improve code and attach to a barbell to measure the values.

2024/02/21 Ultrasonic Sensor 2

KADEN KAFAR - Feb 21, 2024, 3:09 PM CST

Title: Ultra Sensor 2

Date: 2/21/2024

Content by: Kaden Kafar

Present: N/A

Goals: Improve the code and add force to the code.

Content:

```
int trigPin = 11;    // Trigger

int echoPin = 12;    // Echo

int timeDelay = 300; // Time delay between each measurement

double m, inches;

float mass;




void setup() {

  //Serial Port begin

  Serial.begin (9600);

  //Define inputs and outputs

  pinMode(trigPin, OUTPUT);

  pinMode(echoPin, INPUT);

    Serial.print("Enter Mass of lift in lbs: ");

  while (Serial.available() == 0){

  }
```

```
  float mass = Serial.parseFloat() / 2.205;

}



void loop() {

  // Start tracking time for velocity and acceleration measurements.

  long double t1 = micros();

  // Trigger the sensor to take a measurement.

  triggerSensor();

  // Set echoPin as an input

  pinMode(echoPin, INPUT);



  // Convert the time into a distance

  double meters1 = readDistanceMeters(echoPin);     // Divide by 29.1 or multiply by 0.0343

  double inches1 = readDistanceInches(echoPin);   // Divide by 74 or multiply by 0.0135

  // Delay the measurement by a set timeDelay to allow for distance and time to be traveled.

  delay(timeDelay);

  // Trigger the sensor to run again.

  triggerSensor();

  //Set echoPin as an input.
```

```
pinMode(echoPin, INPUT);



// Convert the time into a distance again.

double meters2 = readDistanceMeters(echoPin);

double inches2 = readDistanceInches(echoPin);

// Take a second time to calculate the velocity

long double t2 = micros();

// Find the time by finding the change in time and dividing by 1000 to get to seconds.

double time = (t2 -t1) /1000;

//Find the change in distnces for meters and inches.

double meters = meters2-meters1;

inches = inches2 - inches1;

//Find the first velocities in both meters and inches.

double vel_meters1 = meters / time;

double vel_inch1 = inches / time;


// Start a third time counter.

long double t3 = micros();

// Trigger the sensor to run for the third time

triggerSensor();
```

```
// Set echoPin as an input.

pinMode(echoPin, INPUT);



// Convert the time into a distance in meters and inches.

double meters3 = readDistanceMeters(echoPin);

double inches3 = readDistanceInches(echoPin);

// Delay the time between the initial and secondary pulse to allow time to travel.

delay(timeDelay);

// Trigger the sensor a fourth time.

triggerSensor();



// Set the echoPin as an input.

pinMode(echoPin, INPUT);



// Convert the time into a distance in meters and inches

double meters4 = readDistanceMeters(echoPin);

double inches4 = readDistanceInches(echoPin);

// Take a fourth time for acceleration measurements.

long double t4 = micros();

// Find the change in time and divide by 1000 to get to seconds.
```

```
double times = (t4 -t3) /1000;

// Find the change in distance in meters and inches.

double meterss = meters4-meters3;

double inchess = inches4 - inches3;

// Find the second velocity in meters and inches.

double vel_meters2 = meterss / times;

double vel_inch2 = inchess / times;

// Find the time from the start of the measurements to the end.

double time2 = (t4 - t1) / 1000;

// Calculate the acceleration fromt he change in velocity over the change in time.

double accelerationInches = (vel_inch2 -vel_inch1) / (time2);

double accelerationMeters = (vel_meters2 - vel_meters1) / time2;

// Calculate the force of the user

double force = accelerationMeters * mass;

Serial.print("Distance(m)(): ");

Serial.print(meters4);

Serial.println();

Serial.print("Velocity(m/s): ");

Serial.print(vel_meters2);

Serial.println();
```

```
  Serial.print("Acceleration(m/s^2): ");

  Serial.print(accelerationMeters);

  Serial.print("Force(N): ");

  Serial.print(force);

  Serial.println();



  delay(100);

}

void triggerSensor() {

  digitalWrite(trigPin, LOW);

  delayMicroseconds(5);

  digitalWrite(trigPin, HIGH);

  delayMicroseconds(10);

  digitalWrite(trigPin, LOW);

}

double readDistanceInches(int echoPin) {

  return pulseIn(echoPin, HIGH) / 74 / 2;

}

double readDistanceMeters(int echoPin) {

  return pulseIn(echoPin, HIGH) / 2910 / 2;
```

```
}
```

```
The code was cleaned up and added force measurements of based on the accelerations
```

Conclusions/action items:

Find a proper radar sensor to track movement better.

2024/03/19 Fabrication Protocol

James Waldenberger - Mar 19, 2024, 9:49 PM CDT

Title: Fabrication Protocol

Date: 3/19/2024

Content by: Group

Present: N/A

Goals: Create a protocol to follow during the fabrication process to have easy and repeatable results while making the prototype.

Content: PDF version also attached

Timeline: Gantt Chart

Materials and costs table:

em	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	QTY	Cost Each	Total	Link
adar Attachment										
F Transmitter and eceiver	RF Transmitter/Receiver between ultrasonic sensors and display	KW-Commerce	38819_m000523	Amazon		3/19	1	$9.99	$9.99	url
lax Ultrasonic	Ultrasonic Sensor	Max Sonar	MB1020-000	MaxBotix		3/14	2	$29.95	$59.90	url
yroscope	Used to orient the direction of the ultrasonic sensor	TBD	TBD	TBD	TBD	TBD	2	TBD	TBD	TBD
ousing Block	3D Printed Housing chamber	TBD	TBD	Makerspace	TBD	TBD	2	TBD	TBD	TBD
creen Attachment										
isplay Screen	Flexible display attached to center of barbell	TBD	TBD	TBD	TBD	TBD	1	TBD	TBD	TBD
ousing Block	3D printed housing chamber for screen and raspberry pi	TBD	TBD	Makerspace	TBD	TBD	1	TBD	TBD	TBD
eneral Components										
ower Supply	Batteries used to supply both radar attachments and screen attachment	TBD	TBD	TBD	TBD	TBD	3	TBD	TBD	TBD
elco	Used to attach housing blocks to barbell	TBD	TBD	TBD	TBD	TBD	~128 mm	TBD	TBD	TBD
/ire Components	Extra electrical components to attach everything	TBD	TBD	Makerspace	TBD	TBD	TBD	TBD	TBD	TBD
eavy Duty Nylon	Used as straps for barbell and screen attachments	TBD	TBD	TBD	TBD	TBD	1x2ft	TBD	TBD	TBD
								Total:		

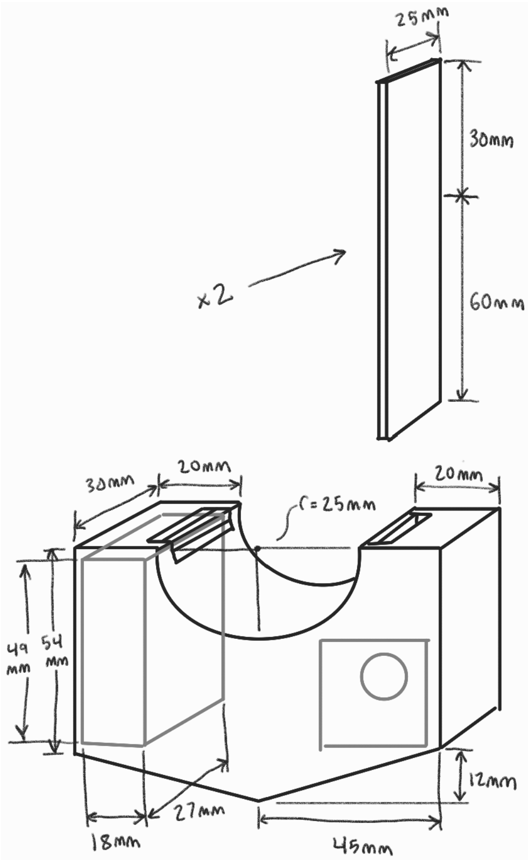
Fabrication Details

1. **Name of Fabrication step/portion of prototype:** Radar attachment

   Date to be completed: 4/22/24

   Team member(s) fabricating: Kaden Kafar and Jacob Parsons

   Detailed sketch of portion of prototype being fabricated (w/ dimensions):



   Detailed bulleted steps of fabrication:

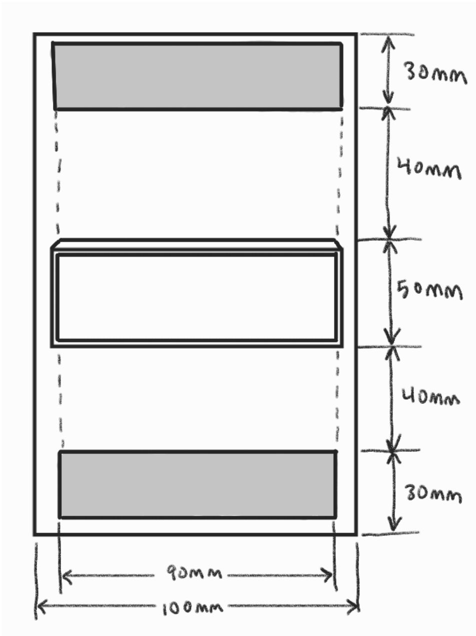
1. Gather ultrasonic sensor, wireless transmitter, power supply, gyroscope, velcro, wire components, and 3D printed housing block (*add printer, filament, and printing settings after print*)
2. Solder ultrasonic sensor outputs (pulse-width, analog voltage, and RS232 serial) to the inputs of wireless transmitter
3. Repeat step b for second ultrasonic sensor
4. Solder gyroscope outputs to an input of wireless transmitter
5. Attach ultrasonic sensors, gyroscope, and wireless transmitter to the power supply
6. Insert both ultrasonic sensors at the bottom of the housing block with their transceivers in the openings
7. Place the gyroscope inside of the housing chamber along with the power supply
8. Orient the wireless transmitter on the near side of the housing chamber (near side is the side nearest to the center of the barbell, see picture)
9. Cut two 25x70mm straps of nylon fabric and two 25x25mm patches of velcro with scissors
10. Sew velcro to the end of each strap, making two straps that can attach to each other
11. Attach straps to the housing chamber by wrapping strap around slot and sewing it shut leaving 70mm of strap to wrap around barbell
12. Repeat step k for other strap on opposite side, make sure velcro patches are oriented the same way

2. **Name of Fabrication step/portion of prototype:** Screen Attachment

   Date to be completed: 4/22/24

   Team member(s) fabricating: Nolan BlomWillis and James Waldenberger

   Detailed sketch of portion of prototype being fabricated (w/ dimensions):



   Detailed bulleted steps of fabrication:

1. Gather velcro, fabric, and display
2. Cut 100x190mm piece of nylon and four 25x90mm patches of velcro with scissors
3. Sew three patches of velcro onto nylon (one in the middle, two on either end as in picture above)
4. The fourth velcro patch will need to be attached to the back side of the display screen with the adhesive material from the velcro strip.
5. Attach display with velcro side of display attached to velcro that was sewed into the middle of the nylon

---

Conclusions/action items:

Follow through with fabrication protocol in the coming weeks and update it as necessary with actual steps taken.

James Waldenberger - Mar 19, 2024, 9:50 PM CDT

Team name: Barbell Injuries

Team members: James Waldenberger, Jacob Parsons, Kaden Kafar, Nolan Blom/Wills

Project title: Preventing Weight Lifting Injuries By Barbell Modifications

Timeline: Gantt Chart

Materials and costs table:

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	QTY	Cost Each	Total	Link
Radar Attachment										
RF Transmitter and Receiver	RF Transmitter/Receiver between ultrasonic sensors and display	KW-Commerce	[illegible]	Amazon		3/19	1	$9.99	$9.99	Url
Max Ultrasonic	Ultrasonic Sensor	Max Sensor	[illegible]	MaxBotix		3/14	2	$29.95	$59.90	Url
Gyroscope	Used to orient the direction of the ultrasonic sensor	TBD	TBD	TBD	TBD	TBD	2	TBD	TBD	TBD
Housing Block	3D Printed Housing chamber	TBD	TBD	Makerspace	TBD	TBD	2	TBD	TBD	TBD
Screen Attachment										
Display Screen	Flexible display attached to center of barbell	TBD	TBD	TBD	TBD	TBD	1	TBD	TBD	TBD
Housing Block	3D printed housing chamber for screen and raspberry pi	TBD	TBD	Makerspace	TBD	TBD	1	TBD	TBD	TBD
General Components										
Power Supply	Batteries used to supply both radar attachments and screen attachment	TBD	TBD	TBD	TBD	TBD	5	TBD	TBD	TBD
Velcro	Used to attach housing blocks to barbell	TBD	TBD	TBD	TBD	TBD	~100 mm	TBD	TBD	TBD
Wire Components	Bits electrical components to attach everything	TBD	TBD	Makerspace	TBD	TBD	TBD	TBD	TBD	TBD
Heavy Duty Nylon	Use disc straps for barbell and screen attachments	TBD	TBD	TBD	TBD	TBD	1x2ft	TBD	TBD	TBD
								Total:		

Download

Fabrication_Protocol_-_Google_Docs.pdf (334 kB)

2024/3/20 Prototype For Show & Tell

James Waldenberger - Mar 21, 2024, 12:20 AM CDT

Title: Prototype For Show & Tell

Date: 3/20/2024

Content by: James Waldenberger

Present: Jacob Parsons

Goals: Create a prototype to show our seniors at the show and tell that showcases the final dimensions of the barbell attachment and the working concept of the ultrasonic sensors.

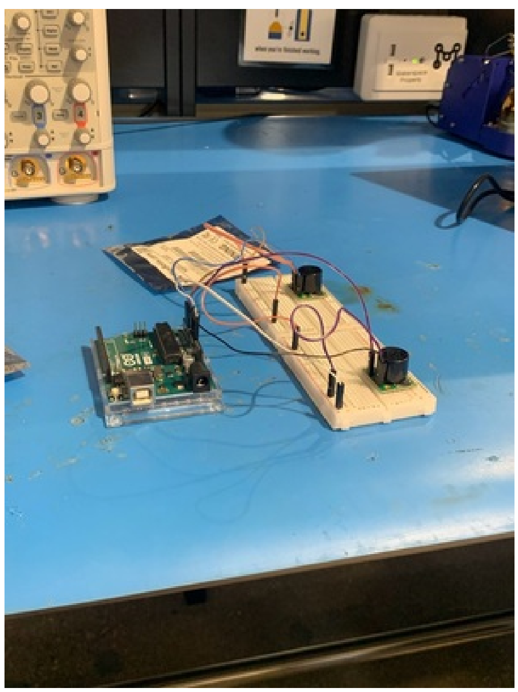
Content:

- Hooked up sensors to Arduino
  - 5V pin, GND pin, and PWM pin
  - Code:
- Made cardboard model of barbell attachment to scale using box-cutter and hot glue
- Some issues with sensor values, seems like analog input pin doesn't work the best -> switch to PWM pin (see above)
- Attached images show prototype and sensor

Conclusions/action items:

Finish prototype for show and tell, make better connections with the sensor and finish up code to give a concise output.

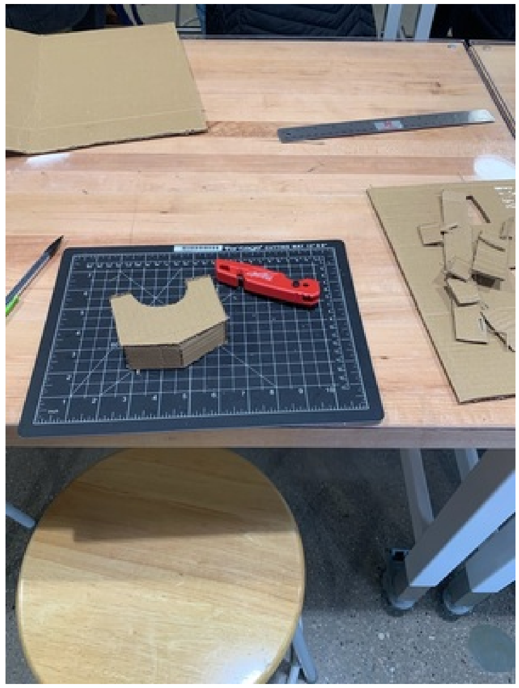
James Waldenberger - Mar 21, 2024, 12:22 AM CDT



Download

Arduino_with_ultrasonic_sensors.jpg (129 kB)

James Waldenberger - Mar 21, 2024, 12:22 AM CDT



Download

Cardboard_model.jpg (166 kB)

2024/04/24 Assembly and Testing

James Waldenberger - Apr 30, 2024, 5:22 PM CDT

Title: Assembly and Testing

Date: 4/24/24

Content by: James Waldenberger

Present: Jacob Parsons

Goals: Assemble 3D printed components and test the ultrasonic sensor circuit.

Content:

3D printed components were completed by the makerspace folk. There are 11 separate components for the print.

- Inner bearing
- Outer bearing with circuit housing
- Lid
- Battery holder
- 5x bearing balls
- 2x bearing holders

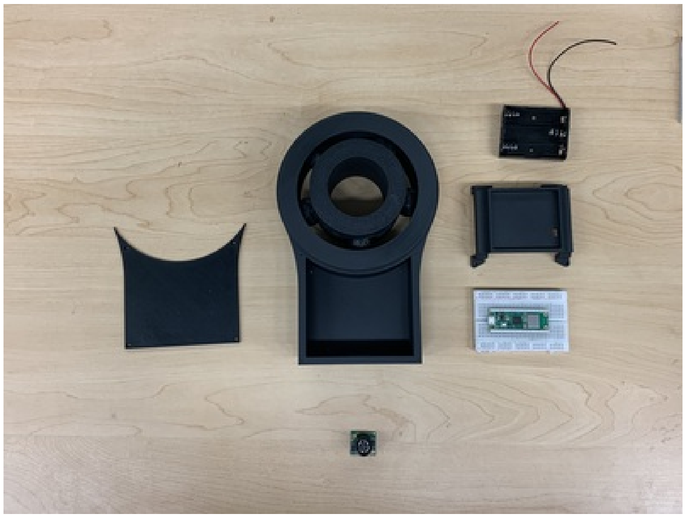
See picture below for how the design looks. CAD files are also available under project files

See testing and results folder for testing protocol and sensor acuity and beam path tests.

Conclusions/action items:

Now that the design is mostly complete, get final deliverables ready and practice for the poster presentation.

James Waldenberger - Apr 30, 2024, 5:26 PM CDT



Download

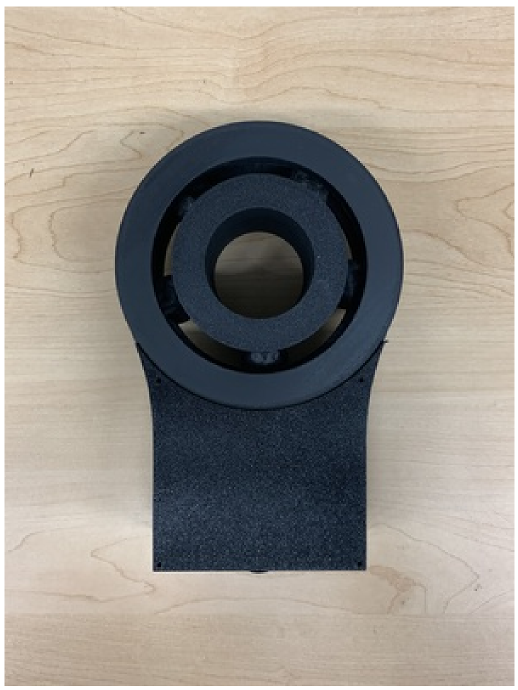
IMG_2612.jpeg (2.03 MB)

James Waldenberger - Apr 30, 2024, 5:26 PM CDT

Download

IMG_2618.jpeg (1.56 MB)

James Waldenberger - Apr 30, 2024, 5:26 PM CDT



Download

IMG_2607.jpeg (2.62 MB)

2024/04/17-Soldering Display

NOLAN BLOMWILLIS - Apr 30, 2024, 9:43 PM CDT

Title: Soldering Display

Date: 2024/04/17

Content by: Nolan BlomWillis

Present: N/A

Goals: Solder pins on display so display can be worked on during fabrication and testing

Content:

Learned how to solder pins to a display at the Team Lab

Completed soldering of display

Conclusions/action items:

Now can work on attachment to barbell(pvc) and work on that for future work.

NOLAN BLOMWILLIS - Apr 30, 2024, 9:44 PM CDT

Download

SolderingDisplay.jpg (318 kB)

2024/05/01 - Updated Fabrication Protocol

Jacob Parsons - May 01, 2024, 4:12 PM CDT

Title: Updated Fabrication Protocol

Date: 5/1/24

Content by: Jacob Parsons

Present: N/A

Goals: Update Fabrication Protocol

Content:

Ultrasonic Sensor Holder

1. Print the bearing holder model from SOLIDWORKS on a 3D printer of your choice using tough PLA (the team used the Ultimaker and Bambu 3D printers)

2. Remove supports from prints and sand down rough edges

3. Insert 5 balls into the ball bearing groove and lock them in with the inside ring, this is the ring that will be in contact with the barbell

4. Secure the balls in place using the bearing holders and M2 screws

5. Insert the battery pack with batteries into the housing chamber, and cover with printed battery holder

6. Connect power supply wires to the breadboard of the Raspberry Pi Pico W (Vcc and GND), and insert the ultrasonic sensor into the hole.

7. Wire the ultrasonic sensor to the Pico W

8. Screw in the battery holder and cover using M2 screws

Functioning Prototype

1. Gather 2 breadboards, the Raspberry Pi Pico W, the Raspberry Pi 4 Model B, the ultrasonic sensor, power supply, serial display, and jumper cables

2. Wire the ultrasonic sensor to the Pico using the pulse wave (PW) pin, Vcc pin, and GND pin on the ultrasonic sensor to the 3.3V pin, GND pin, and a GPIO pin of your choice on the Pico W - make sure to define this GPIO pin in the code

3. Wire the Pico W to the Pi 4 using the Pico W's GND and TX pins, wire these pins to the Pi 4's GND and RX pins respectively

4. Wire the Serial Display to the Pi 4 using the Vcc, GND, and RX pins of the serial monitor and connect these to the 3.3V, GND, and TX pins of the Pi 4

5. Supply the Pico W and Pi 4 with power from the power supply

2024/04/23 - Testing Protocol

Jacob Parsons - Apr 29, 2024, 8:58 PM CDT

JTitle: Testing Protocol

Date:

Content by: Jacob Parsons

Present: N/A

Goals: Establish Testing Protocol for Sensor Acuity Test and Sensor Beam Path Test

Content:

Acuity Test

1. Measure out and mark every 4 inches from 16 inches to 48 inches away from a wall or large obstructing object

2. Connect one of the ultrasonic sensors to the computer and run the code to allow for the sensor to measure distances (can find code under project files)

3. Position ultrasonic sensor at 16 inches and record the value there

4. Move the ultrasonic sensor to 20 inches and record said value, repeat this process all the way up to 48 inches

5. Repeat steps 3 and 4 for 5 trials

6. Repeat steps 2-5 for the other ultrasonic sensor

Beam Path Test

1. Position ultrasonic sensor at least 48 inches away from a wall or obstructing object, make sure the ultrasonic sensor is at least 8 inches from the table or floor

2. At roughly 6 inches from the ultrasonic sensor, slowly move a large obstructing object (like a folder) from far away closer to the ultrasonic sensor until the value recorded changes - mark this position of the obstructing object

3. Repeat this process at 4 inch increments until the last measurement is roughly 38 inches away

4. Measure and record the perpendicular distance (in inches), that was marked in step 2

5. Calculate the angle of the beam path at this position, cot(perpendicular distance / distance from sensor)

2024/03/21 - LV-MaxSensor-EZ Error Testing

Jacob Parsons - Mar 21, 2024, 2:48 PM CDT

Title: LV-MaxSensor-EZ Error Testing

Date: 3/21/24

Content by: Jacob Parsons

Present: Jacob

Goals: Find our the error trends of each ultrasonic sensor

Content:

- Content is attached below

Conclusions/action items:

This will allow for the team to have an acceptable % error when calculating the distances observed by the ultrasonic sensor, this is important to have a range of acceptable values where the distances are "equal" enough.

Jacob Parsons - Mar 21, 2024, 2:49 PM CDT

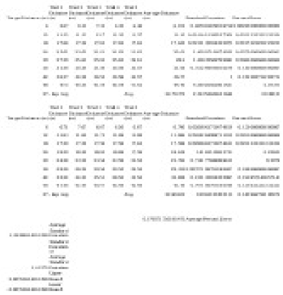
The ultrasonic sensor will be placed at various distances away from an obstructing object, and the observed value will be recorded alongside with the actual value. The ultrasonic sensor will always be placed one inch within to the table and one inch above the table to ensure that the sensor is located at the same relative position throughout all distances away from the obstructing object. This will also limit any error that may occur due to interference with the table, especially since the application of the object will have the ultrasonic sensor facing downwards and open at all angles. This test will be conducted for both LV-MaxSensor-Ez Ultrasonic Sensor, "A" and "B".

Figure 1: Set up of ultrasonic sensor relative to obstructing object

Download

LV-MaxSensor-EZ_Error_Testing.pdf (268 kB) Error Testing Description

Jacob Parsons - Mar 21, 2024, 2:50 PM CDT



Download

ultrasonic_error_testing.xlsx (17.3 kB) Excel spreadsheet of results

2024/04/24 - Sensor Acuity Test and Beam Path Test

Jacob Parsons - Apr 29, 2024, 8:57 PM CDT

Title: Sensor Acuity Test and Beam Path Test

Date: 4/24/28

Content by: Jacob Parsons

Present: Jacob Parsons

Goals: To conduct the sensor acuity tests and beam path tests that were established in the testing protocol.

Content:

- There were two rounds of acuity testing that occurred for both ultrasonic sensors

- The first round was conducted around the time of show and tell. These used the same ultrasonic sensors that will be used for later tests, but the code was run on the Arduino Uno using the Arduino software

- The second rounds of tests were conducted on the Raspberry Pi Pico W and python was used to write this code

- Interestingly, the original acuity testing had an average percent error of around 20%, while the second round only had a percent error of around 1.5%

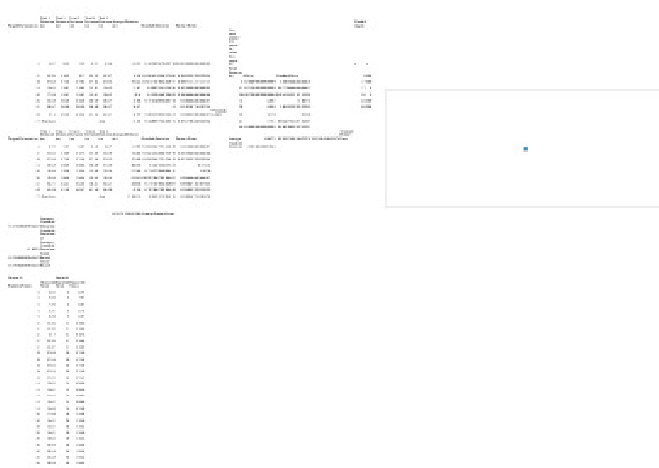
- There is no confirmed explanation for why this occurred, but my best guess is that the code ran a lot more efficiently on the Pico W and the more secure wire connections lead to more consistent measurements.

- Only 1 round of the beam path testing was conducted, and it can be observed that the ultrasonic sensor beam path has a maximum width that occurs around 3 feet

Conclusions/action items:

The conclusions from this testing ensured the team multiple things. First, the ultrasonic sensors that were used are precise and accurate, this validates the use of them since it also means that the device is precise and accurate - these types of measurements are important since the safety of the lifter is at risk. The second conclusion - from the beam path testing - is that the maximum beam distance from the center of the ultrasonic sensor was around 10 inches. This distance is small enough that nobody walking by the lift would give false readings - without running into the barbell at least.

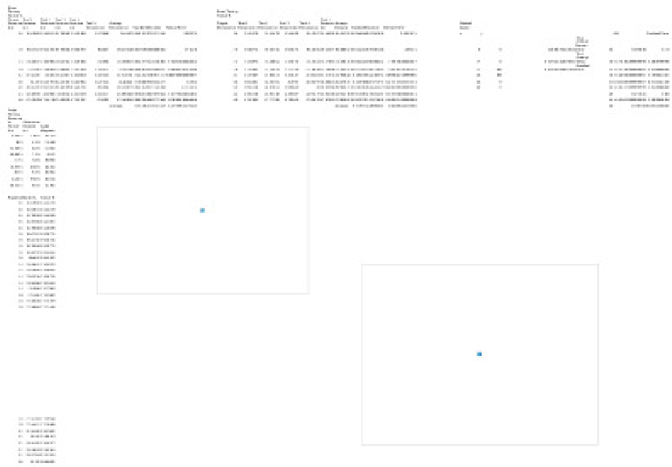
Jacob Parsons - Apr 29, 2024, 8:44 PM CDT



Download

ultrasonic_error_testing.xlsx (21.4 kB) Original measurements of sensor acuity test with Arduino Uno and poorer wire connections

Jacob Parsons - Apr 29, 2024, 8:45 PM CDT



Download

second_sensor_tests.xlsx (29.7 kB) Sensor acuity test and beam path results using the Raspberry Pi Pico W and soldered connections

2024/04/22 - Measuring Code

Jacob Parsons - Apr 29, 2024, 8:21 PM CDT

Title: Measuring Code

Date: 4/22/24

Content by: Jacob Parsons

Present: N/A

Goals: Write code that will be used to measure distances with ultrasonic sensor and send this information to raspberry pi 4 model B from raspberry pi pico w.

Content:

- See code below

Conclusions/action items:

This code is for the Raspberry pi pico w. For the future, it will need to be integrated into the bluetooth/wifi code so it can wirelessly transmit the recorded values to the raspberry pi 4 model b.

Jacob Parsons - Apr 29, 2024, 8:14 PM CDT

```
import machine
import time

uart = machine.UART(0, baudrate = 9600, tx = machine.Pin(0), rx = machine.Pin(1))

def measure_pulse_duration(pin, timeout=30000):
    start_time = 0
    end_time = 0

    while pin.value() == 0:
        pass

    start_time = time.ticks_us()

    while pin.value() == 1:
        if time.ticks_diff(time.ticks_us(), start_time) > timeout:
            return 0

    end_time = time.ticks_us()

    pulse_duration = time.ticks_diff(end_time, start_time)

    return pulse_duration

while True:
    pin = machine.Pin(28, machine.Pin.IN)
    pulse_duration = measure_pulse_duration(pin)
    distance = pulse_duration/147
    print("Pulse duration: ", pulse_duration, "us")
    print("Distance: ", distance, "in")

    uart.write("{},{}\n".format(pulse_duration, distance))

    time.sleep(1)
```

Download

pico_code.pdf (26.3 kB)

2024/04/22 - Display Code

Jacob Parsons - Apr 29, 2024, 8:31 PM CDT

Title: Display Code

Date: 4/22/24

Content by: Jacob Parsons

Present: N/A

Goals: To compare the value of the distance that is being received from the raspberry pi pico w and display if the value is higher, lower, or equivalent to 1 foot

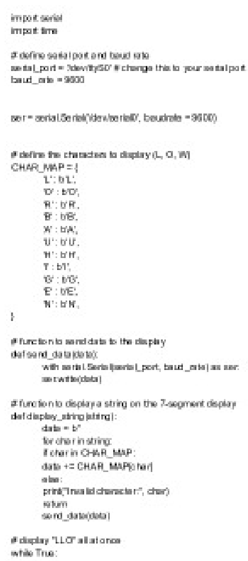
Content:

See below

Conclusions/action items:

In the future, this will compare the distance values received from either ultrasonic sensor. It will also need to be updated to receive the information wireless.

Jacob Parsons - Apr 29, 2024, 8:31 PM CDT



```
import serial
import time

# define serial port and baud rate
serial_port = '/dev/ttyS0' # change this to your serial port
baud_rate = 9600


ser = serial.Serial('/dev/serial0', baudrate = 9600)


# define the characters to display (L, O, W)
CHAR_MAP = {
        'L' : b'L',
        'O' : b'O',
        'R' : b'R',
        'B' : b'B',
        'A' : b'A',
        'U' : b'U',
        'H' : b'H',
        'I' : b'I',
        'G' : b'G',
        'E' : b'E',
        'N' : b'N',
}

# function to send data to the display
def send_data(data):
        with serial.Serial(serial_port, baud_rate) as ser:
        ser.write(data)

# function to display a string on the 7-segment display
def display_string(string):
        data = b''
        for char in string:
        if char in CHAR_MAP:
        data += CHAR_MAP[char]
        else:
        print("Invalid character:", char)
        return
        send_data(data)

# display "LLO" all at once
while True:
```

Download

display_code.pdf (32.9 kB)

2024/05/01 CAD Files

James Waldenberger - May 01, 2024, 7:15 PM CDT

Title: CAD Files

Date: 5/1/24

Content by: James Waldenberger

Present: N/A

Goals: Consolidate all CAD files used in the project to this one place here in the design notebook for ease of access.

Content:

See attachments below for all of the CAD models/assemblies of the sensor attachment (made by Kaden)

Conclusions/action items:

Complete final deliverables for the semester!

KADEN KAFAR - May 01, 2024, 8:23 PM CDT

Download

Assembly.zip (4.98 MB)

4/14/24 Ethical Considerations

James Waldenberger - Apr 14, 2024, 2:25 AM CDT

Title: Ethical Considerations

Date: 4/14/24

Content by: James Waldenberger

Present: Nolan BlomWillis, Kadan Kafar

Goals: Think about parts of the project that require some considerations with regard to ethics and outline how that will affect the design process and potential business model of the project moving forward.

Content:

- What components of your design have ethical dimensions (be specific and list at least 2)?

1. Testing of the device leads to unsavory results in terms of effectiveness to thwart bodybuilding injuries.
2. Possible failure of the device if something blocks a sensor could lead to bodily harm to the user.

- How will your team address the ethical dimensions? (What is your action plan?)
    - If testing of the device shows that it is not capable or underwhelmingly able to prevent injuries during bench pressing there is no case where we should push for the device to be on the market. Instead, we should go back to the drawing board and determine what part of the design is lacking and then do another round of testing to determine if our tweaks were able to improve the device’s ability at its intended job. If not, then repeat the steps again.
    - A sensor being blocked is not something that we can really prevent because that is just an inherent way that the sensing works. We can, however, provide the user with a set of guidelines for device use and a proper warning about keeping the workout area clear at all times.

Conclusions/action items:

Refer to the action plans if these ethical dilemmas come to pass, otherwise update with more ethical considerations as they're thought of (complete with an action plan).

2024/01/31 - Barbell injuries

NOLAN BLOMWILLIS - Feb 02, 2024, 12:19 AM CST

Title: Research on Barbell Injuries

Date: 1/31/2024

Content by: Nolan BlomWillis

Present: Myself

Goals: Wanting to gain an understanding of the most common injuries when using a barbell in powerlifting.

Search Term: [PubMed] Searched: "Acute and Chronic Strength Training Injuries"

Citation:

[1] V. Bengtsson, L. Berglund, and U. Aasa, “Narrative review of injuries in powerlifting with special reference to their association to the squat, bench press and deadlift,” *BMJ Open Sport & Exercise Medicine*, vol. 4, no. 1, p. e000382, Jul. 2018, doi: https://doi.org/10.1136/bmjsem-2018-000382.

Content:

-Powerlifting is increasing amongst both men and women

-Elite to sub-elite powerlifters report **18-46%** of injuries are due to the **Benching** exercise

-Elite to sub-elite powerlifters report **12-31%** of injuries are due to the **Deadlift** exercise

-Elite to sub-elite powerlifters report **22-32%** of injuries are due to the **Squatting** exercise

-Grip width for Bench press no more than 81cm between index fingers

-The main muscles used in this lift are "pectoralis major, triceps brachii, and the anterior deltoid muscle."

-Since these lifts demand multiple muscles and joints to work together it is thought that the cause of these injures could be related to the excessively heavy loads, the large range of motion during the exercises, insufficient resting times between training sessions and/or faulty lifting technique.

-Rupture of the pectoralis major was the most common injury reported when bench press injuries were searched across databases.

-Meniscus injuries were the most common deadlift injury and was far and away the winner.

-Two clinical commentaries regarding instability in the barbell during the bench press

-3/38 studies reported suboptimal lifting techniques as the cause for the injuries.

-Heavy load and fatigue were main contributors

-Different techniques can modulate the compressive, shear, and rotational forces on the joints.

Conclusion/Action Items:

- Look into the research linked to this article, 15. Lavallee ME, Balam T. An overview of strength training injuries: acute and chronic. *Curr Sports Med Rep* 2010;9:307–13. 10.1249/JSR.0b013e3181f3ed6d [PubMed] [CrossRef] [Google Scholar] [Ref list]

-17. Reeves RK, Laskowski ER, Smith J. Weight training injuries: part 1: diagnosing and managing acute conditions. *Phys Sportsmed* 1998;26:67–96. 10.3810/psm.1998.02.939 [PubMed] [CrossRef] [Google Scholar] [Ref list]

2024/02/01-Acute and Chronic Injuries

NOLAN BLOMWILLIS - Feb 02, 2024, 12:15 AM CST

Title: Research on Barbell Injuries

Date: 2/1/2024

Content by: Nolan BlomWillis

Present: Myself

Goals: Wanting to gain an understanding of the most common injuries when using a barbell in powerlifting.

Search Term: [PubMed] Searched: "Acute and Chronic Strength Training Injuries"

Citation:

[1] M. E. Lavallee and T. Balam, "An Overview of Strength Training Injuries," *Current Sports Medicine Reports*, vol. 9, no. 5, pp. 307–313, Sep. 2010, doi: https://doi.org/10.1249/jsr.0b013e3181f3ed6d.

Content:

-Acute injury is due to a rapid onset of the symptoms of injury

-These Sudden/Acute injuries count for around 60-75% of all injuries

-Acute can go down to nonemergent and emergent types

-Muscular strain and Ligament strain are the two most likely acute injuries

-Chronic injuries have a longer onset time

-Chronic could be over the span of years

-Velocity related injuries could occur with the barbell lifts

-Velocity related means muscular movement at too high of a velocity.

Conclusion/Action Items:

-17. Reeves RK, Laskowski ER, Smith J. Weight training injuries: part 1: diagnosing and managing acute conditions. *Phys Sportsmed* 1998;26:67–96. 10.3810/psm.1998.02.939 [PubMed] [CrossRef] [Google Scholar] [Ref list]

2024/02/01-Diagnosing Acute injuries

NOLAN BLOMWILLIS - Feb 02, 2024, 12:14 AM CST

Title: Diagnosing acute injuries

Date: 02/01/2024

Content by: Myself

Present: Myself

Goals: Understand the diagnosing of acute injuries and learn more about the acute injuries

Search Term: [PubMed] Searched "Weightlifting Injuries"

Citation:

[1] R. K. Reeves, E. R. Laskowski, and J. Smith, "Weight Training Injuries," *The Physician and Sportsmedicine*, vol. 26, no. 2, pp. 67–96, Feb. 1998, doi: https://doi.org/10.3810/psm.1998.02.939.

Content:

-Probable risk factors include improper technique

-The improper technique could be due to imbalance with the bar

-RICE method is usually the go to method for acute Musco skeletal injuries

-Tendon aversion and compartment syndrome along with sprains and strains show up most frequently in acute weightlifting injuries.

Conclusions/action items:

Look into common poor weightlifting techniques.

2024/02/01-Upperbody weightlifting injuries

James Waldenberger - Feb 05, 2024, 11:22 PM CST

Title: Upper Body weightlifting injuries

Date: 02/01/24

Content by: Myself

Present: Myself

Goals: Gain a better understanding of specifically upper body weightlifting injuries since that would be the barbell fix we would be looking to help with the benching barbell injuries

Search Term: [PubMed] Searched "Weightlifting Injuries"

Citation:

[1] K. Golshani, M. E. Cinque, P. O'Halloran, K. Softness, L. Keeling, and J. R. Macdonell, "Upper extremity weightlifting injuries: Diagnosis and management," *Journal of Orthopedics*, vol. 15, no. 1, pp. 24–27, Nov. 2017, doi: https://doi.org/10.1016/j.jor.2017.11.005.

Content:

-Close to 1 million weight lifting injuries end up as an emergency visit every year

-Pectoralis tendon ruptures are very common in weightlifting injuries

-46%-70% of pectoralis tendon ruptures result from benching

-Bicep Tendon rupture is the other injury that is commonly found weightlifting

-Specifically at a weight of 68kg or more does this really become a risk. (68kg = 150lbs)

-Bicep Curls or rowing motion is what leads to these ruptures

-Exercises that emphasize larger muscle groups may create an imbalance of the internal versus external rotator cuff musculature, rotator cuff-deltoid force couple, and periscapular musculature.

-Shoulder Injuries are mostly related to an imbalance in the rotator cuff in lifts

-Need to balance smaller group muscle training with the large group muscle training

Conclusions/action items:

2024/02/08-Patent regarding motion sensors

NOLAN BLOMWILLIS - Feb 08, 2024, 9:47 PM CST

Title: Rigid Body Motion Sensor

Date: 2/8/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Gain an understanding of patents related to motion sensors

Content:

- Computerized system for measuring rigid body movements.

- Anchored vs non anchored segment of body is what is being looked at

- The use of joint angles for anchored vs non anchored body segments

-Sending one or more signals and actions to a processor that creates an action is not allowed

-Having a computer-generated skeletal map from the sensor is a no

Conclusions/action items:

Use this document to check over what has already been done so no legal.

2024/02/21-Patent regarding Radar technology

NOLAN BLOMWILLIS - Feb 22, 2024, 8:59 PM CST

Title: Patent research for Radar

Date: 2/21/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Gain an understanding of what is out in the realm of radar technology

Content:

[1] S. H. Schmalzl, "Radar system with balancing of the receiving channels over a plurality of radar chips." https://patents.google.com/patent/US20210311164A1/en?q=(Radar+balance)&oq=Radar+balance (accessed Feb. 21, 2024).

- Two radar chips in the device is a touchy area

- Claim 1 out of 17 said "A radar system, comprising: a first radar chip having one or more first receiving channels;"

-Looking at the type of receiving channels

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2024/02/02 Annotated Bibliography

NOLAN BLOMWILLIS - Feb 02, 2024, 1:07 AM CST

Title: Annotated Bibliography

Date: 02/02/2024

Content by: Nolan BlomWillis

Present: Myself

Goals: Create an annotated bibliography for four sources to be used in research for design project.

Content:

[1] K. Golshani, M. E. Cinque, P. O'Halloran, K. Softness, L. Keeling, and J. R. Macdonell, "Upper extremity weightlifting injuries: Diagnosis and management," *Journal of Orthopedics*, vol. 15, no. 1, pp. 24–27, Nov. 2017, doi: https://doi.org/10.1016/j.jor.2017.11.005.

This article addresses more specifics regarding the types of upper extremity injuries that are most likely to occur when weightlifting. To start, it gives a brief overview of different population statistics regarding weightlifting injuries. The most interesting one that I found was regarding the fact that very close to one million people each year are sent to the emergency department due to these weightlifting injuries.

Next, the article went in depth about the three top injuries to occur in the upper body due to weightlifting. The first one which will be the most beneficial to gain information on is the pectoral tendon ruptures which results from the bench press 45-70% of the time. The other two were not as likely to occur due to the bench press and barbell which is the task at hand from the client. This document will be used to reference the statistics of weightlifting injuries for our preliminary research.

[2] M. E. Lavallee and T. Balam, "An Overview of Strength Training Injuries," *Current Sports Medicine Reports*, vol. 9, no. 5, pp. 307–313, Sep. 2010, doi: https://doi.org/10.1249/jsr.0b013e3181f3ed6d.

This article really opened up the doors to acute and chronic injuries. This was something that was mentioned in other articles researched but this one dug deeper into the specifics around them and what the treatment for each looks like. For example acute injuries with quick onset usually use the RICE method whereas chronic injuries usually result in either surgery or lots of physical therapy.

The most useful piece of information from this article that was not related to chronic or acute injuries was the velocity related injuries. This means that the injury stems from movements that were sped up faster than the muscles could handle in stress causing stress or strains on the muscle. This could be beneficial for my project to look into possibly adding a design component that will track proper speed for a lift. There already are applications on someones phone they could use but this would be directly on the equipment being used.

[3] R. K. Reeves, E. R. Laskowski, and J. Smith, "Weight Training Injuries," *The Physician and Sportsmedicine*, vol. 26, no. 2, pp. 67–96, Feb. 1998, doi: https://doi.org/10.3810/psm.1998.02.939.

This article discusses the process for diagnosing and treating acute injuries in the weightroom. Not a lot of new information came from this document but what did come from it will be important considerations for the totality of this project. For example, the article talked briefly about how improper technique is one of the leading causes for acute injuries. The balance of the bar or the imbalance would be improper technique. If the group can figure out how to track the balance of the bar while in use this could prevent the acute injuries that occur from this common improper technique.

[4] V. Bengtsson, L. Berglund, and U. Aasa, "Narrative review of injuries in powerlifting with special reference to their association to the squat, bench press and deadlift," *BMJ Open Sport & Exercise Medicine*, vol. 4, no. 1, p. e000382, Jul. 2018, doi: https://doi.org/10.1136/bmjsem-2018-000382.

This article was the most helpful as it was a review article so it was a pathway for many other articles that were in the realm of weightlifting injuries. This article also did a great job and has lots of helpful statistics regarding where injuries in the weightroom occur most often based on type of lift. For example, the most injury prone lift of the big three (Squat, Bench Press, and Deadlift) was the bench press which has around 18-46% of weightlifting injuries.

I will be coming back to this article and diving deeper into more research regarding the articles that were linked in this review article. This article had a lot of broad information regarding the different injuries but ultimately was just a review so it did not go too in depth. Most focus of this dive will be in relation to the bench press section which already occurred when finding a different source regarding upper body injuries related to weightlifting.

Conclusions/action items:

Go more in depth in research specifically using the review article from the annotated bibliography.

2024/02/08 - Motion Sensor Calibration Research

NOLAN BLOMWILLIS - Feb 08, 2024, 8:47 PM CST

Title: Calibration Research

Date: 2/8/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Gain an understanding of what calibration should look like to understand shelf life and service use

Content:

- Application variables is a big contributor to wear on sensors

- Misapplied sensors is something that should be watched out for

- Sensors should be calibrated once a year for best use

- Improper installation could lead to faulty sensors or more frequent

- Natural sensor drift is the other cause that leads to a need for calibration

Conclusions/action items:

Take this information to the PDS

2024/02/15-Radar Research

NOLAN BLOMWILLIS - Feb 15, 2024, 10:00 PM CST

Title: Radar Research

Date: 02/15/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Gain knowledge on how small sized radar technology works

Content:

[1] J. G. Argañarás, Y. T. Wong, R. Begg, and N. C. Karmakar, "State-of-the-Art Wearable Sensors and Possibilities for Radar in Fall Prevention," *Sensors*, vol. 21, no. 20, p. 6836, Oct. 2021, doi: https://doi.org/10.3390/s21206836.

- This article is related to fall prevention and radars related to that.

- **Gait Analysis**- Systematic study of human movement during locomotion.

- Try and understand Gait analysis for arm movements

- Processing, Floor Sensors, clinical testing are the options for non wearable radar devices.

- Wearables can be used in-lab and free living. We would work on free living application as this would not be in a lab

Types of sensors to use for wearable device are the following

- IMUs
- Force
- Pressure
- Angle / Bend
- EMGs
- OPtical TOF
- Ultrasound
- Radar

-Radar will probably be the best option for our application

Conclusions/action items:

Look into the different types of sensors used for radar devices

2024/02/15-Lidar Research

NOLAN BLOMWILLIS - Feb 15, 2024, 10:04 PM CST

Title: Radar Research

Date: 02/15/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Gain knowledge on how small sized radar technology works

Content:

[1] "What is LiDAR and How Does it Work? | Synopsys," *www.synopsys.com*. https://www.synopsys.com/glossary/what-is-lidar.html

- Lidar stands for Light detection and ranging

-In use of balance, it would detect if light is blocked on ends of the barbell due to an imbalance

-Mostly used for distance sensing

- Usually used for self driving cars but could be applied to barbell

- Looks at reflected pulse from an object based on its initial pulse. Could be used as a side of the barbell being the object measuring pulse from.

Problems with Lidar include:

- Isolation and rejection of a signal

- Debris in the way of lidar

- Limitations on optical power

- Dangerous to human eyes

Conclusions/action items:

NOTE: Lidar can be a safety concern for human eyes, other people in the gym would be harmed

2024/03/08-Gyroscope Research

NOLAN BLOMWILLIS - Mar 08, 2024, 8:5

Title: Gyroscope research

Date: 03/08/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Gain an understanding of a gyroscope

Content:

[1] D. Peterson, *Control Automation*, Feb. 19, 2024. https://control.com/technical-articles/accelerometers-and-gyroscopes-understanding-the-metrics-of-motion/#:~:text=Similar%20to%20the%20accelerometer%2C%20a%20gyroscope%20can%20sense,gyroscope%20excels%20at%20measuring%20rotation%2C%20or%20tilt

-Senses changes in directional motion

-Measures rotations and tilt angles

-Difference between the object movement and rotating mass is the angle

-Six different degrees of freedom which is good to pair with sensors that do not have much in terms of directional freedom.

Conclusions/action items:

Use this info to relate to barbell application

2024/03/08-Display notes

NOLAN BLOMWILLIS - Mar 08, 2024, 1:29 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

-Need to have a receiver for the transmitters giving a signal to the display/receiver

Conclusions/action items:

2024/3/13-Receiver research

NOLAN BLOMWILLIS - Mar 13, 2024, 10:32 AM CDT

Title: Receiver research

Date:

Content by: Nolan BlomWillis

Present: Myself

Goals: Research different receivers that could be applicable to the design

Content:

Common barbell is 7 feet or 2.1 meters long so need a receiver that can pickup signal from that far away.

-MICRF220AYQS-TR Microchip Technology | RF and Wireless | DigiKey This receiver is 2 bucks a pop, 5mmx6mm in size so small enough for application, 300-450Hz

-SX1239IMLTRT Semtech Corporation | RF and Wireless | DigiKey receiver is close to 4 bucks a pop, around 5.7mmx5.7mm in size, 450,850,900Hz

Conclusions/action items:

2024/3/13-Velcro attachment

NOLAN BLOMWILLIS - Mar 13, 2024, 10:40 AM CDT

Title: Velcro Attachment

Date: 03/13/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Find different options for velcro to use for barbell attachment

Content:

Want no bigger than six inches of a display so velcro should not be bigger than that.

Conclusions/action items:

2024/17/4-Soldering Display

NOLAN BLOMWILLIS - Apr 17, 2024, 1:19 AM CDT

Title: Soldering display pins

Date: 4/17/2024

Content by: Nolan BlomWillis

Present: Myself

Goals: Solder display pins to be able to use display for prototype

Content:

Today I went to the makerspace and got a soldering lesson done. Then I acquired a display and the pins needed to have the display attach to a breadboard.

Conclusions/action items:

Now I will discuss with my team the best route to take for the velcro attachment

NOLAN BLOMWILLIS - Apr 17, 2024, 1:19 AM CDT

Download

SolderingDisplay.jpg (318 kB)

Barbell Bench

KADEN KAFAR - Jan 31, 2024, 1:49 PM CST

Title: "Effect of Barbell Weight on the Structure of the Flat Bench Press"

Date: 1/31/2024

Content by: Kaden Kafar

Present: N/A

Goals: Conduct research on bench press and prevention of injury.

Content:

-Found on Scopus using search words, Bench and Smart

-https://oce.ovid.com/article/00124278-201705000-00021/PDF

-Emg tables with values for major muscles participating in the lift.

-Tables containing data of different percent loads of the individuals max load.

-Findings on the ascending vs descending phases of the bench press.

Conclusions/action items:

-Conduct more research on injury during bench press as well as competing patents.

Bench Press Injuries

KADEN KAFAR - Jan 31, 2024, 3:22 PM CST

Title: "Narrative review of injuries in powerlifting with special reference to their association to the squat, bench press and deadlift"

Date: 1/31/2024

Content by: Kaden Kafar

Present: N/A

Goals: Find ways that bench pressing causes injury

Content:

-Searched pubmed for bench press injuries.\

-https://bmjopensem.bmj.com/content/bmjosem/4/1/e000382.full.pdf

-Analyzes injuries of the 3 major lifts, Bench, deadlift and squat

-Given reports of what muscles are injured during each process.

-Given reports of failure due to bad form or pushing muscles to breaking point.

Conclusions/action items:

-Complete annotated bibliography by Friday.

Radar

KADEN KAFAR - Feb 09, 2024, 12:24 PM CST

Title: Radar Research

Date: 2/9/2024

Content by: Kaden Kafar

Present: N/A

Goals: conduct research on the viability of radar as the primary sensor

Content:

-googled https://www.baumer.com/us/en/product-overview/distance-measurement/radar-sensors/c/291

-Sends radio waves to bounce off walls and sense distances.

-fairly cheap option

-Good stable signal in most conditions

-quick measurement of distances.

Conclusions/action items:

-Conduct research on other options

Lidar

KADEN KAFAR - Feb 09, 2024, 12:31 PM CST

Title: Lidar research

Date: 2/9/2024

Content by: Kaden Kafar

Present: N/A

Goals: Research Lidar as a sensor option.

Content:

-googled, https://velodynelidar.com/what-is-lidar/

-Uses pulsed light waves to detect distances

-Uses multiple lidar sensors to cover blind spots.

-can create a full map of the room

-used in automated cars.

Conclusions/action items:

-Conduct research on other viable options.

Leveling Barbell

James Waldenberger - Jan 31, 2024, 8:58 PM CST

Title: "Barbell level indicator (US9623285B1)

Date: 1/31/2024

Content by: Kaden Kafar

Present: N/A

Goals: Find competing patents

Content:

-Google patents searching using barbell balance

-https://patents.google.com/patent/US9623285B1/en?q=(%22Barbell%22+electronic)&oq=%22Barbell%22+electronic

1. A barbell level indicator for detecting movement of a barbell, the barbell level indicator comprising:

    a housing shaped to fit adjacent a barbell;

    one or more magnets positioned within the housing for securing the housing to the barbell;

    an accelerometer secured within the housing

    an alarm; and

    a microprocessor located within the housing and in electronic communication with a memory, the accelerometer, and alarm for:

        receiving acceleration data and data related to an angle of the barbell level indicator from the accelerometer and storing accelerometer data on the memory; and

        determining the angle of the barbell level indicator with the microprocessor based on accelerometer data stored on the memory;

        storing a limit angle on the memory; and

        emitting a warning on the alarm when the angle of the barbell level indicator is determined by the microprocessor to exceed the limit stored on the memory.

    2. The barbell level indicator of claim 1, further comprising a short-range communications module in electrical communication with the microprocessor for transmitting data related to the angle and movement of the barbell level indicator from the accelerometer to a mobile device.

    3. The barbell level indicator of claim 1, wherein the alarm comprises an audible alarm configured to emit an audible signal when the angle of the barbell level indicator is greater than the limit angle.

    4. The barbell level indicator of claim 2, wherein the alarm comprises one or more visual indicators configured to illuminate when the angle of the barbell level indicator is determined by the processor to be greater than the limit angle stored on the memory.

    5. The barbell level indicator of claim 4, wherein the alarm further comprises one or more LED lights configured to illuminate when the angle of the barbell level indicator is greater than the limit angle.

    6. The barbell level indicator of claim 3 further comprising a push button in electrical communication with the microprocessor for calibrating an initial angle of the barbell level indicator.

    7. The barbell level indicator of claim 2, wherein the short-range communications module comprises a Bluetooth® transmitter.

8. A barbell level indicator for detecting movement of a barbell, the barbell level indicator comprising:

    a housing shaped to fit adjacent a barbell, the housing including a concave bottom portion shaped to adapt to the barbell;

    one or more magnets positioned within the housing and along the concave bottom portion of the housing for securing the housing to the barbell;

    an accelerometer secured within the housing;

an alarm;

a microprocessor located within the housing and in electronic communication with a memory, the accelerometer, and alarm for:

receiving acceleration data and data related to an angle of the barbell level indicator from the accelerometer and storing accelerometer data on the memory;

determining with the microprocessor a number of repetitions of an exercise with the barbell based on the accelerometer data measured by the accelerometer and stored on the memory;

determining a angle of the barbell level indicator with the microprocessor based on data related to the angle of the barbell level indicator stored on the memory;

storing a limit angle on the memory;

emitting a warning on the alarm when the angle of the barbell level indicator is determined by the microprocessor to exceed the limit angle stored on the memory;

a short-range communications module in electrical communication with the microprocessor for transmitting the data related to movement of the barbell from the accelerometer to a mobile device.

9. The barbell level indicator of claim 8, wherein the alarm comprises a buzzer alarm configured to emit an audible signal when the angle of the barbell level indicator is greater than the limit angle.

10. The barbell level indicator of claim 8, wherein the alarm comprises one or more LED lights configured to illuminate when the angle of the barbell level indicator is greater than the limit angle.

11. The barbell level indicator of claim 1, further comprising determining with the microprocessor a number of repetitions of an exercise with the barbell based on acceleration data measured by the accelerometer and stored on the memory corresponding to raising and lowering of the barbell.

- Main takeaways are that we have to find a new way to track the bar and possibly not in a magnetic sleeve.

Conclusions/action items:

-Find any other patents relative to the project.

Camera system

KADEN KAFAR - Jan 31, 2024, 2:07 PM CST

Title: "Multi-functional weight rack and exercise monitoring system for tracking exercise movements (US10737140B2)"

Date: 1/31/2024

Content by: Kaden Kafar

Present: N/A

Goals: Find competing patents.

Content:

-Searched on google patents by barbell tracking

1. An exercise monitoring system for use with exercise equipment, comprising:

 a camera assembly comprising:

 a first camera that captures first visible light images of a user of said exercise equipment, and

 a second camera that generates an image comprising a matrix of distance values;

 a motorized driver, mechanically coupled to said camera assembly within a housing, that moves said camera assembly in at least one degree of freedom to track a movement of at least one object in a field of view of said at least one imaging sensor;

 a processor coupled to said camera assembly and receiving said matrix of distance values from said camera assembly, said processor further performing analysis of said matrix of distance values to generate information relating to monitored exercise activity of said user;

 a controller, in data communication with said processor, and coupled to said motorized driver, which controls movement of said motorized driver so as to track the movement of said object;

 said housing containing each of said camera assembly, motorized driver, processor and controller, the housing mechanically coupled to said motorized driver to move the camera assembly with respect to said housing, and further configured to mechanically couple said exercise monitoring system to an external support;

 the system further comprising:

 an interactive device, physically separate from said housing, said interactive device configured to receive and display said information relating to monitored exercise activity of said user, wherein said interactive device further comprises a front-facing camera that captures second visible light images of said user, said second visible light images taken from a different perspective than said first visible light images, and

 wherein said first visible light images, said second visible light images, and said information relating to monitored exercise activity of said user are transmitted to a remote database for storage.

2. The system of claim 1, said first camera comprising a visible light image capture camera assembly.

3. The system of claim 1, said second camera comprising a three-dimensional camera assembly.

4. The system of claim 3, said three-dimensional camera assembly comprising a plurality of infra-red image sensors, spatially separated from one another and configured and arranged to capture respective infra-red imagery and further being coupled to a processor that computes a position for each pixel in a multi-pixel position image based on said infra-red imagery from each of the plurality of infra-red image sensors.

5. The system of claim 3, said three-dimensional camera assembly comprising a plurality of visible light image sensors, spatially separated from one another and configured and arranged to capture respective visible light imagery and further being coupled to a processor that computes a position for each pixel in a multi-pixel position image based on said visible light imagery from each of the plurality of visible light image sensors.

6. The system of claim 1, said housing further comprising one or more mechanical attachment members that secure the system to a support member of said exercise equipment.

7. The system of claim 6, said mechanical attachment members comprising a strap that secures the system to a support member of said exercise equipment or another fixed member with respect thereto.

8. The system of claim 1, said motorized driver comprising a motor that applies reversible torque through a gear to rotate said camera assembly about an axis of rotation to adjust an angular position of said camera assembly with respect to said housing.

9. The system of claim 1, further comprising a communications module.

10. The system of claim 1, further comprising a tilt angle sensor that determines an angular position or displacement of said camera assembly and provides an output indicative of said angular position or displacement.

11. The system of claim 10, said tilt angle sensor comprising an accelerometer.

12. The system of claim 1, wherein said interactive device is in data communication with said system's processor, and including an interactive device processor in the interactive device, a user interface display, and instructions stored and executed in said interactive device processor and including instructions implementing an exercise activity program on said interactive device.

13. The system of claim 1, further comprising a server, in data communication with said system's processor, the server including a server processor executing instructions therein implementing a machine learning program running on the processor and trained on said server.

14. The system of claim 1, said processor and said controller being integrated into a common circuit on a circuit board disposed in said housing.

15. A method for tracking an exercise routine of a user, comprising:

providing an exercise monitoring system in a housing mountable to an exercise machine;

collecting first visible light images using a first camera in said housing;

collecting imagery using at least one distance-measuring camera assembly in said exercise monitoring system, the imagery containing information regarding an object of interest in said exercise machine;

generating a multi-pixel position image from said imagery that codifies, for each pixel in the multi-pixel position image, a distance from a reference point to a corresponding point on said object of interest;

performing analysis of said multi-pixel position image to generate information relating to monitored exercise activity of said user; and

moving said camera assembly of said exercise monitoring system with respect to the housing, using a motorized driver within and mechanically coupled to said housing, as necessary to track a position of said object of interest and to keep said object of interest within a field of view of said camera apparatus,

wherein providing said exercise monitoring system includes disposing said distance-measuring camera assembly and a motor and a motor controller configured and arranged to controllably move said camera assembly within said housing;

receiving and displaying, via an interactive device that is physically separate from said housing, said information relating to monitored exercise activity of said user,

capturing, using a front-facing camera of said interactive device, second visible light images of said user, said second visible light images taken from a different perspective than said first visible light images, and

transmitting to a remote database for storage said first visible light images, said second visible light images, and said information relating to monitored exercise activity of said user.

16. The method of claim 15, further comprising presenting to a user of said exercise monitoring system, on said interactive device, information regarding the user's performance on said exercise machine.

17. The method of claim 15, further comprising accepting from a user of said exercise monitoring system, via an interactive device coupled thereto, user identification information to log the user in to an interactive program running on said interactive device.

18. The method of claim 15, further comprising exchanging real-time data between said interactive device and a server coupled to said interactive device over a data communication network.

19. The method of claim 15, further comprising calculating one or more metrics regarding a performance of said user on said exercise machine.

20. The method of claim 15, further comprising implementing a biometric recognition step on said interactive device so as to recognize a user.

21. The method of claim 20, said biometric recognition step including a step of facial recognition of said user.

-Design using camera systems to track barbell object and compute data for the user to access.

Conclusions/action items:

-Find any other potential patents for the project.

Annotated Bibliography

KADEN KAFAR - Feb 02, 2024, 10:32 AM CST

Title: Annotated bibliography

Date: 1/31/2024

Content by: Kaden Kafar

Present: N/A

Goals: Create an annotated bilbliography using 4 sources.

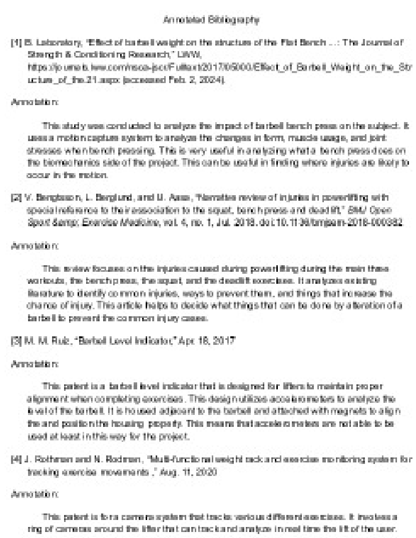
Content:

Attached

Conclusions/action items:

N/A

KADEN KAFAR - Feb 02, 2024, 10:32 AM CST



Annotated Bibliography

[1] B. Laboratory, "Effect of barbell weight on the structure of the Flat Bench ...: The Journal of Strength & Conditioning Research," LWW, https://journals.lww.com/nsca-jscr/Fulltext/2017/05000/Effect_of_Barbell_Weight_on_the_Structure_of_the.21.aspx (accessed Feb. 2, 2024).

Annotation:

This study was conducted to analyze the impact of barbell bench press on the subject. It uses a motion capture system to analyze the changes in form, muscle usage, and joint stresses when bench pressing. This is very useful in analyzing what a bench press does on the biomechanics side of the project. This can be useful in finding where injuries are likely to occur in the motion.

[2] V. Bengtsson, L. Berglund, and U. Aasa, "Narrative review of injuries in powerlifting with special reference to their association to the squat, bench press and deadlift," *BMJ Open Sport & Exercise Medicine*, vol. 4, no. 1, Jul. 2018. doi:10.1136/bmjsem-2018-000382

Annotation:

This review focuses on the injuries caused during powerlifting during the main three workouts, the bench press, the squat, and the deadlift exercises. It analyzes existing literature to identify common injuries, ways to prevent them, and things that increase the chance of injury. This article helps to decide what things that can be done by alteration of a barbell to prevent the common injury cases.

[3] M. M. Rub, "Barbell Level Indicator," Apr. 18, 2017

Annotation:

This patent is a barbell level indicator that is designed for lifters to maintain proper alignment when completing exercises. This design utilizes accelerometers to analyze the level of the barbell. It is housed adjacent to the barbell and attached with magnets to align the and position the housing properly. This means that accelerometers are not able to be used at least in this way for the project.

[4] J. Rothman and N. Rodman, "Multi-functional weight rack and exercise monitoring system for tracking exercise movements," Aug. 11, 2020

Annotation:

This patent is for a camera system that tracks various different exercises. It involves a ring of cameras around the lifter that can track and analyze in real time the lift of the user.

Download

Annotated_Bibliography.pdf (49.9 kB)

Ultrasonic sensor system

KADEN KAFAR - Feb 22, 2024, 1:44 PM CST

Title: Ultrasonic Sensor System

Date: 2/22/2024

Content by: Kaden Kafar

Present: N/A

Goals: Design a system using ultrasonic transceivers

Content:

https://www.cuidevices.com/product/sensors/ultrasonic-sensors/ultrasonic-transceivers/cusa-tr80-18-2400-th

-Create a cap to place at end of barbell that scans around barbell to detect distances

-Create a circular enclosure that attaches to the end of the barbell

Conclusions/action items:

2024/01/30 - Electromyographic and Kinematic Evaluation of Bench Press Notes

Jacob Parsons - Jan 31, 2024, 7:35 PM CST

Title: Electromyographic and Kinematic Evaluation of Bench Press Notes

Date: 1/30/24

Content by: Jacob Parsons

Present: N/A

Goals: Learn more about the different EM activation during bench and the biomechanic basics

Citation:

Searched "muscle activation during bench press" in PubMed

A. Bellitto *et al.*, “Electromyographic and kinematic evaluation of Bench Press Exercise: A case report study on athletes with different impairments and expertise,” *Sport Sciences for Health*, vol. 19, no. 2, pp. 723–732, May 2022. doi:10.1007/s11332-022-00949-6

Content:

- The purpose of the study is to observe the kinematic and electromyographic differences observed during the bench press for a varying range of skillsets (1 unimpaired and 3 Paralympic athletes)

- They specifically looked at the symmetry and coordination between the arms and the motor availability during the movement.

- The conclusion of the study was that it showed the techniques used are able to be applied to evaluate a larger range of individuals during bench press.

- Besides the physical benefits to exercising, there are a lot of other social and mental benefits that come along with it. So the importance of minimizing injury whilst doing this healthy activity is important so the individual is able to keep doing it.

- A various amount of muscles are used during the lift: primarily there are the pectoralis major, deltoids, and traps used to press; then there are the biceps and forearm muscles that act as dynamic stabilizers; and finally there are various trunk muscles that are recruited to maintain a stable position while benching

- All subjects are elite powerlifters

- The subjects benched 90% of their 1RM during the trial phase (after a proper warmup)

- Kinematic data was acquired with a motion capture system with markers on the bar, arms, and shoulders, and hips.

- Electromyographic data was collected with surface level probes at various muscle groups (trapezius, ant. deltoid, pec. major, biceps, triceps, and rectus abdominus)

- The data acquisition was synchronized as well

- The study acted as a proof of concept to observe the different muscle strategies enacted by various individuals during the movement (para and not)

Conclusions/action items:

This article applies to the project in a manner that if the team would like to analyze the muscle activation or the joint symmetries and synchronization of the user whilst using our modified barbell, the techniques and observations used in the article are a way to do so. Further research will need to be done on electrodes and motion capture techniques, or alternatives to not have the cameras in the gym due to different gym policies or personal preferences of the user or other gym goers. This article is something that should be looked back upon in the future if this is the route the team elects to go.

Jacob Parsons - Jan 30, 2024, 10:04 PM CST

CASE REPORT

Electromyographic and kinematic evaluation of bench press exercise: a case report study on athletes with different impairments and expertise

Amy Bellitto · Giorgia Marchesi · Micaela Camini · Antonino Massone · Maura Casadio · Alice De Luca

Abstract

Purpose With an increase in the number of adapted sports, the need to monitor sports performance in people with different abilities has grown. Indeed, a thorough evaluation of the sports gesture could prevent the occurrence of injuries, enable a continuous performance assessment, and allow to verify the compliance of the requirements for the competitions. Gesture kinematics provides an assessment of performance, while the muscle activities reveal the underlying strategies adopted by each athlete. In this context, we propose an instrumented evaluation to assess performance in Para-powerlifting. Our goal is to define and test a setup and a protocol to quantitatively assess the execution of bench press exercise in athletes with different abilities.

Methods We recruited an unimpaired athlete and three Paralympic athletes. They were requested to execute the bench press exercise while we recorded muscle activity and kinematic data from the upper body. We investigated the sport gesture by extracting parameters describing coordination, symmetry, and synchronism between arms, and motor variability while repeating the gesture.

Results Paralympic athletes performed the gestures with higher coordination between arms and low variability across repetitions compared to the unimpaired athlete, who was not at the Olympic level. All participants obtained similar kinematic performance by adopting different muscle strategies.

Conclusions This study is a proof of concept that the instrumented evaluation proposed here can allow to conduct a complete assessment of the bench press exercise, in terms of kinematics, muscle activity and performance in athletes with different abilities.

Keywords Bench press · Paralympic athletes · Muscle strategies · Sensorimotor disabilities

Introduction

The number of people with disabilities involved in sports and physical activities is rapidly increasing. Studies have shown that active participation in sports has a positive impact on the quality of life of people with disabilities by promoting personal health (mental and physical wellbeing), stimulating individual development (increase in self-confidence and improved self-esteem) and enabling social interaction, inclusion and integration [1–3]. These are probably the reason behind the recent growth of adapted sports and the increase in the number of para-athletes. Indeed, more than 4000 athletes from 162 nations competed in the last Paralympic Games (Tokyo 2020–2021) which set a world-wide record for the highest number of athletes in a game.

Springer

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s11332-022-00949-6.pdf (969 kB)

2024/01/31 - Barbell Bench Grip Width Notes

Jacob Parsons - Jan 31, 2024, 8:03 PM CST

Title: Barbell Bench Grip Width Notes

Date: 1/31/24

Content by: Jacob Parsons

Present: N/A

Goals: Learn about the physical effects of different barbell grip widths

Citation:

Searched "Bench press injuries" in UW Libraries search with the article drop down selected and the scholarly box checked

C. M. Green and P. Comfort, “The Affect of Grip Width on Bench Press Performance and Risk of Injury,” *Strength and Conditioning Journal*, vol. 29, no. 5, pp. 10–14, Oct. 2007.

Content:

- The article observed that a wider grip - over 1.5 times that of shoulder width - may lead to an increased risk of shoulder injury for the athlete (pec. major rupture, ant. shoulder instability, or a stress failure at the distal clavicle). More narrow grips have no substantial affect on muscle recruitment (less than 5%) in one rep.

- Shoulder abduction of 90 degrees is an "at risk position", meaning there is a higher likelihood of an injury occurring whilst the shoulder is put under a load

- Studies show that pec. major tears usually occur during the eccentric position since the muscle is under the greatest amount of tension then

- Also muscle recruitment changed minimally from shoulder width to nearly twice shoulder width while the narrower the grip, the higher activation of the triceps

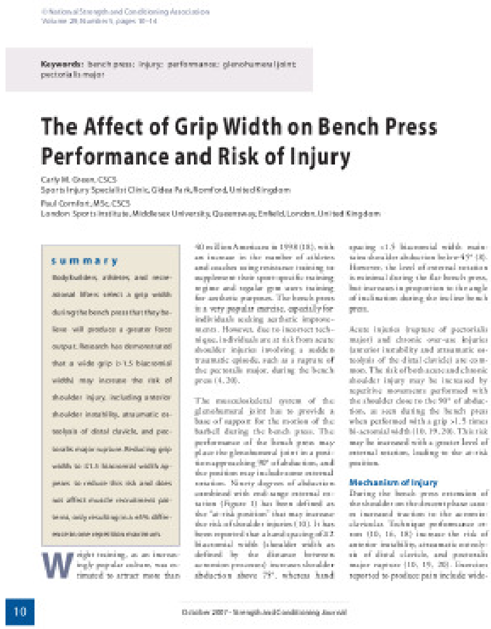
- Also closer grips have a smaller shoulder abduction than wider grips, which can help prevent injury

- The bar should also be lowered to the chest in a controlled manner and then moved up at a rapid pace.

Conclusions/action items:

This article proved important in finding the best grip to reduce injury. Whilst modifying the bench press, the team can take into account having some sort of marker or indicator to show the user where to not exceed their grip placement - while it is generally common practice to be within 1.5 shoulder with. Also the team can indicate either during the movement or afterward to the user if the pace of the workout and the movement pattern were consistent with a safe rep or not.

Jacob Parsons - Jan 31, 2024, 1:48 PM CST



Keywords: bench press; injury; performance; glenohumeral joint; pectoralis major

The Affect of Grip Width on Bench Press Performance and Risk of Injury

Carly M. Green, CSCS
Sports Injury Specialist Clinic, Gidea Park, Romford, United Kingdom
Paul Comfort, MSc, CSCS
London Sports Institute, Middlesex University, Queensway, Enfield, London, United Kingdom

[Download](#)

The_Affect_of_Grip_Width_on_Bench_Press_Performance_and_Risk_of_Injury.pdf (197 kB)

2024/02/01 - Quantity of Lifting Injuries Notes

James Waldenberger - Feb 05, 2024, 11:21 PM CST

Title: Quantity of Lifting Injuries Notes

Date: 2/1/24

Content by: Jacob Parsons

Present: N/A

Goals: Figure out how many injuries occur in the weight room

Citation:

Searched "pectoralis major tears" in PubMed

H. A. Bukhary *et al.*, “Prevalence and pattern of injuries across the weight-training sports,” *Cureus*, Nov. 2023. doi:10.7759/cureus.49759

Content:

- The purpose of the article is to identify if there is a pattern among weightlifting injuries

- A form was filled out for members of health clubs across Saudi Arabia and then one was chosen randomly

- The most common injured part of the body was the shoulder (7.4%), which is relevant to bench pressing

- The study found a significance between injury and the amount of weight being lifted (0.017 with an alpha value = 0.05)

- The most common types of injuries included inflammation/pain due to bending (5.9%), torsion (3.6%), ligament/muscle tear (3.8%), stripped off (2.3%)

Conclusions/action items:

This article shows the significance in the attempt to modify a barbell to prevent bench press injuries. The most common injury location is the shoulder, which is one of the major injury locations for bench press. Any way of decreasing the amount of injuries is beneficial, that is both changing the equipment and spreading around accurate and helpful information to new and existing lifters of all levels.

2024/01/28 - Barbell Pads Research

Title: Barbell Pads Research

Date: 1/28/2024

Content by: Jacob Parsons

Present: N/A

Goals: Learn more about barbell pads

Content:

Sources:

- Searched best barbell pads on Google for the 1st link, the following links were attached to the 1st.

[1] A.-C. Mallory Creveling, “The best barbell pads, according to a personal trainer,” Verywell Fit, https://www.verywellfit.com/best-barbell-pad-5120808 (accessed Jan. 28, 2024).

[2] “Dark Iron Fitness 17" Extra thick barbell neck pad, shoulder support for weight lifting, Crossfit, powerlifting,” Walmart.com, https://www.walmart.com/ip/Dark-Iron-Fitness-17-Inch-Extra-Thick-Crossfit-Powerlifting-More-Fits-2-Olympic-Size-Bars-Smith-Mach/437921918?clickid=Rdw0t4T50xyPTEMQXVWukXN9UkHzYzTUES0s0Y0&irgwc=1&sourceid=imp_Rdw0t4T50xyPTEMQXVWukXN9UkHzYzTUES0s0Y0&veh=aff&wmlspartner=imp_10078&affiliates_ad_i (accessed Jan. 28, 2024).

[3] “Weider Protective Weight Bar Pad with hook-and-loop Velcro closure,” Walmart.com, https://www.walmart.com/ip/Weider-Protective-Weight-Bar-Pad-with-Hook-and-Loop-Velcro-Closure/62 clickid=Rdw0t4T50xyPTEMQXVWukXN9UkHzYzTQES0s0Y0&irgwc=1&sourceid=imp_Rdw0t4T50xyPTEMQXVWukXN9UkHzYzTQES0s0Y0&veh=aff&wmlspartner=imp_10078&affiliates_ad_ (accessed Jan. 28, 2024).

[4] A. D. Savage, “DP,” Amazon, https://www.amazon.com/dp/B073G8VN4N?tag=verywellfit-onsite-prod-20&linkCode=ogi&th=1&ascsubtag=5120808%7Cn2be0c82896374080a289791528f9f5

Summary:

- A quick google search on "best barbell pads" yielded the 1st source above; while the website is likely biased in some ways, the purpose of this research is to gain general information about the overall best [2], the best for your budget [3], and the most comfortable [4].

- The best overall pad is from Dark Iron Fitness, and costs $31.08. The pad is said to be <u>durable</u>, <u>soft</u>, and <u>comfortable</u>; however, it is *not as thick* as opposing pads - according to the website. It <u>flatten</u> and is <u>sweat resistant</u>.

- The best for your budget pad is from Weider, and it costs $10.14. The pad's pros are that its <u>inexpensive</u> and <u>soft</u>, but it can feel *stiff* - according to the website. On Walmart it has a rating of 4. with the only alarming points is that one person stated it would *not fit an Olympic sized bar* and it may be *too thick f*or some users.

- Finally the most comfortable bar is from Pro Fitness and it costs $19.95 on Amazon. From the website, it states that the pad is <u>soft, comfortable,</u> and <u>secure</u> - but it does *require a little work to* There were many positive comments, with the only points of concern being that the *straps are not very secure* and that the pad has potential to move; but these were very few of the many review

Conclusions/action items:

All the products are made of some sort of dense foam. This means that while cutting into it is a possibility, a more minimally invasive alteration to the device would be preferred to keep the integr

2024/01/30 - Various Bar Speed Tracker Notes

Jacob Parsons - Jan 31, 2024, 2:07 PM CST

Title: Various Bar Speed Tracker Notes

Date: 1/30/24

Content by: Jacob Parsons

Present: N/A

Goals: To learn about various bar speed trackers and some of the technology behind them

Citation:

- Searched Barbell speed trackers on Google

C. Valle, “Complete Guide to Bar Speed Trackers,” Stronger by Science, https://www.strongerbyscience.com/complete-guide-to-bar-speed-trackers/ (accessed Jan. 30, 2024).

Content:

- Time and displacement are necessary in tracking speed (obviously since v = d/t)

- The article's author selected 3 bar tracking technologies that they believe are the best

<u>Bar Sensei</u>

- $400 ish

- Uses accelerometers to track the bar, and sends information to an iPad via Bluetooth (low-energy)

- Wireless, not wearable

- Tracks many things on top of bar speed

<u>Gymaware</u>

- "Very expensive"

- Very consistent

- Uses a cable attached to the bar

<u>Push Pad</u>

- $200 ish

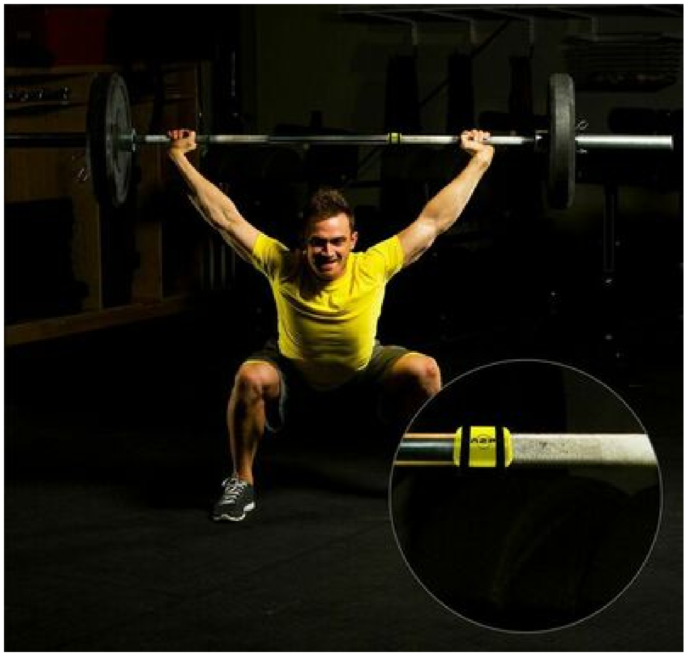
- Wearable

- I am unable to find the product

Conclusions/action items:

Looking into the mechanical patents of each of the devices would be important to understand the technology behind them and how they work. However, our client is looking for something "new", so these devices are not something we can likely replicate - especially the one with the accelerometer since he stated a disinterest in it. However, upon thinking of his idea of "radar" the only potential issue is maintaining a constant direction for the device to look.

Jacob Parsons - Jan 31, 2024, 11:00 AM CST



Download

barsensei.jpg (55.1 kB) Bar Sensei

Jacob Parsons - Jan 31, 2024, 11:04 AM CST

Download

gymaware.jpg (96.2 kB) Gymaware

2024/02/01 - Standard Barbell Patent

Jacob Parsons - Feb 01, 2024, 11:15 PM CST

Title: Barbell Patent

Date: 2/1/24

Content by: Jacob Parsons

Present: N/A

Goals: Learn about the dimensions of the barbell so when a device is designed it can be fitted properly

Citation:

Searched "barbell" into Google Patents

[1] W. Henniger, “Barbell,” D843,524. Mar. 19, 2019. Available: https://patents.google.com/patent/USRE49513E1/en?q=(barbell)&oq=barbell

From here found a non - patent citation to the barbells that are used at UW Recwell Centers

[2] “The rogue bar 2.0,” Rogue Fitness, https://www.roguefitness.com/the-rogue-bar-2-0-blbr (accessed Feb. 1, 2024).

Content:

- This is an "Olympic bar", so if another bar is the target - other dimensions will need to be used

- The bar is 86.75" long in total

- The loadable sleeve length is 16.40", which leaves 53.95" of middle space in which the user can grasp the bar

- The diameter of the bar is 1.122"

- The middle third of the "holdable" (middle 53.95") bar has no "knurl" - which is the abrased part, while the outer 2/3 have abrasion

- The bar is coated in zinc

Conclusions/action items:

This patent will be useful for the project since a barbell modification is the core goal of this semester. So, knowing the dimensions will help the team know the dimensional constraints for the device.

2024/02/01 - Annotated Bibliography

Jacob Parsons - Feb 01, 2024, 11:27 PM CST

Title: Annotated Bibliography

Date: 2/1/24

Content by: Jacob Parsons

Present: N/A

Goals: Cite the 4 sources and provide an annotation to why it is relevant to the project

Content:

[1] A. Bellitto *et al.*, “Electromyographic and kinematic evaluation of Bench Press Exercise: A case report study on athletes with different impairments and expertise,” *Sport Sciences for Health*, vol. 19, no. 2, pp. 723–732, May 2022. doi:10.1007/s11332-022-00949-6

The client spoke on the idea of placing electrodes on the major contributing muscle groups used during a barbell bench and having that data be sent to a phone app. This article looked at different electromyographic data during bench press. So this article would be useful if the team does end up recording the electromyographic data during the exercise, this article will be a starting point in how to measure and analyze this data.

[2] C. M. Green and P. Comfort, “The Affect of Grip Width on Bench Press Performance and Risk of Injury,” *Strength and Conditioning Journal*, vol. 29, no. 5, pp. 10–14, Oct. 2007.

The article cited above spoke on how hand placement can have an affect on the odds of being injured during the bench press movement - which ended up advising the athlete to avoid benching with 1.5x shoulder width to have a better chance at staying healthy. This can be used by the team for them to design a marker for the user to use or observe on where they should/shouldn't place their hands during the bench.

[3] H. A. Bukhary *et al.*, “Prevalence and pattern of injuries across the weight-training sports,” *Cureus*, Nov. 2023. doi:10.7759/cureus.49759

The importance of designing a modification to a barbell or a device to prevent injury is the main focus of the project, and the article spoke on various barbell related injuries during exercise. There are numerous juries that can occur from bench press, and this article reflected how they can occur at higher percentages in comparison to other lifts due to missknowledge of the equipment or proper technique, or even using too much weight.

[4] W. Henniger, “Barbell,” D843,524. Mar. 19, 2019. Available: https://patents.google.com/patent/USRE49513E1/en?q=(barbell)&oq=barbell

The patent of a standard barbell will be important in knowing the design constraints that are required for a device to fit to the barbell - if the team elects to go in that direction. It also describes the materials used, so if various electrical components or chemicals are used in the product, it is best to check that they are compatible with the barbell prior to production and use.

2024/02/08 - Ultrasonic Instruments for Circuitry

Jacob Parsons - Feb 08, 2024, 8:33 PM CST

Title: Radar Instruments for Circuitry

Date: 2/8/24

Content by: Jacob Parsons

Present: N/A

Goals: To find various radar options to attach to circuitry.

Citation:

"Results for 'ultrasonic+sensor,'" Search Results for ultrasonic+sensor - SparkFun Electronics, https://www.sparkfun.com/search/results?term=ultrasonic%2Bsensor (accessed Feb. 8, 2024).

Content:

- Various ultrasonic sensors found on Spark fun include 3 that would be viable to use for basic arduino code, or another simple programming language

- HC-SR04 3.3V, $5.95

- This one has a maximum range of 4 meters and a minimum range of 2cm with a measuring angle of 15 degrees, it requires 15 mA of current and has a frequency of 40 Hz

- HC-SR04 5V, $4.50

- It has the same range distance of 2 cm - 4 cm and also requires 15 mA of current, it has a measuring angle of 15 degrees as well

- Sparkfun HC-SR04, $17.95

- This one also ranges from 2 cm to 4 cm, it has an operating voltage of 3.3V and a detecting angle of 15 degrees as well

- All 3 of these options seem equally viable and are all roughly the same size

Conclusions/action items:

If the team were to use some sort of radar, as the client suggested, then using an ultrasound distance sensor that is compatible with arduino is viable. A velocity can be determined due to the changing distances over time, and a rep counter can also be set up. The only potential issues is the device picking up on other objects within the detecting range - this could skew rep counts or speeds of the bar. So testing and further research on code and precision will need to be done before this is deemed a viable approach.

2024/02/21 - Affordable Radar and Lidar Options

Jacob Parsons - Feb 22, 2024, 8:10 PM CST

Title: Affordable Radar and Lidar Options

Date: 2/21/24

Content by: Jacob Parsons

Present: N/A

Goals: To find viable radar/lidar options to test code and device.

Citation:

[1] A. Industries, “Garmin lidar-lite optical distance LED sensor,” adafruit industries blog RSS, https://www.adafruit.com/product/4441 (accessed Feb. 22, 2024).

[2] Atom Lidar,” Oz Robotics, https://ozrobotics.com/shop/atom-lidar-a-cost-effective-ranging-module-based-on-tof-technology/ (accessed Feb. 22, 2024).

[3] Sen-18009 Sparkfun Electronics | Development Boards, KITS, ..., https://www.digikey.com/en/products/detail/sparkfun-electronics/SEN-18009/14113835 (accessed Feb. 23, 2024).

[4] Amazon.com: MakerFocus Lidar range finder sensor module TF-Luna, ..., https://www.amazon.com/Single-Point-Compatible-Rasppbarry-Communication-Interface/dp/B088NVX2L7 (accessed Feb. 23, 2024).

[5] Sen-16826 Sparkfun Electronics | entwicklungsboards, -kits, ..., https://www.digikey.de/de/products/detail/sparkfun-electronics/SEN-16826/15652897 (accessed Feb. 23, 2024).

Content:

Lidar:

- From source 1, there is the Garmin lidar optical distance LED sensor, it is priced at $59.95.

- It is compact, 2.1" x 0.8" x 0.9" and has a 1 cm resolution

- It has a range from 5 cm to 10 m, 200 Hz rate

- From source 2, there is that Atom LIDAR sensor, it costs $49.00

- It is 17mm x 42 mm x 15 mm, and it has a range from 0.2 m to 12 m

- IR LED source, 500 Hz frame rate

- From source 3, Spark fun LIDAR sensor that costs $81.25

- It is a Garmin LIDAR-lite, see source 1, with an extension board

- From source 4, MarkerFocus LIDAR sensor that costs $24.99

- 4.13" x 2.64" x 0.59", has a range of 0.2 - 8 m

- 100 Hz default rate

Radar:

- From source 5, Sparkfun Radar sensor that costs $59.95

- Raspberry Pi platform, 1.3" x 1.55"

- 26 pin

2024/03/19 - RF Transmitter/Receiver

Jacob Parsons - Mar 19, 2024, 1:08 PM

Title: RF Transmitter/Receiver

Date: 3/19/24

Content by: Jacob Parsons

Present: N/A

Goals: Find RF Transitter/Receiver

Content:

[1] KWMobile. (n.d.-a). kwmobile 433 *MHz RF Transmitter and Receiver Module*. Amazon. https://www.amazon.com/kwmobile-Transmitter-Receiver-Control-Raspberry/dp/B01H2D2RH6/ref=asc_df_B01H2D2RH6/?tag=hyprod-20&linkCode=df0&hvadid=647294719904&hvpos=&hvnetw=g&hvrand=9391901066736839516&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018948&hvtarg 301631766949&psc=1&mcid=5c9f1a6f625a3d99a7bb39b641d83826

[2] HiLetgo, “HiLetgo 315 MHz RF Transmitter and Receiver Module,” Amazon, https://www.amazon.com/HiLetgo-Transmitter-Receiver-Arduino-Raspberry/dp/B00LNADJS6/ref=asc_df_B00LNADJS6/?tag=hyprod-20&linkCode=df0&hvadid=198093960169&hvpos=&hvnetw=g&hvrand=9391901066736839516&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018948&hvtarg 319099859202&psc=1&mcid=7b1266f5f777381a90e5a6e79def0315&gclid=CjwKCAjw7-SvBhB6EiwAwYdCAdRr2emPzhru5SXF3mFHMa8YgRhXnsL0sgsvh6sujJUpVAauu7ZiqxoCwUwQAvD_BwE (accessed Mar. 19, 2024).

[3] george7378 and Instructables, “Super simple raspberry pi 433mhz home automation,” Instructables, https://www.instructables.com/Super-Simple-Raspberry-Pi-433MHz-Home-Automa (accessed Mar. 19, 2024).

- I found both of these compatible RF transmitter and receiver modules, one with a 433 MHz and another with 315 MHz transmitter

- In other literature I've seen more tutorials be made with 433 MHz transmitters; however, they should likely work equally

- The greater amount of frequency allows for a larger available bandwidth

- Source 3 is a tutorial that uses modules similar to that of source 2

2024/02/15 - Basic Radar Ideas

Jacob Parsons - Feb 16, 2024, 11:01 AM CST

Title: Basic Radar Ideas Notes

Date: 2/15/24

Content by: Jacob Parsons

Present: N/A

Goals: Jot down some ideas on how radar design could work

Content:

- This idea would have either a modified barbell or a barbell attachment, paired with twin devices on the floor beneath the bar path.

- The basic idea of this system is that there will be an outgoing wave emitted from the floor to the bar (or vice versa, whichever has less potential for error) and the position and velocity of the bar is able to be tracked

- Bar speed can be easily calculated via finding the velocity of the bar

- Stability of the bar can be determined by comparing the position of each side of the barbell

- Reps can be counted either by seeing when the bar has gone through one cycle of hitting a threshold distance away from the ground, or by looking at when the velocity of the bar alternates its second time.

- A button on the barbell can be used to initiate and terminate each set as well, so any distance or velocities calculated before or after are neglected and are not taken into account for measuring reps or bar speed.

- The modified bar or barbell attachments must also display the reps and bar position.

Conclusions/action items:

Potential room for error in this device is that the radar could pick up on other objects in the weight room, such as somebody walking by - or the waves being reflected off of another surface or individual. This device would be very code dependent as well.

1/31/24 Paralympic Bench Press Analysis

James Waldenberger - Feb 01, 2024, 11:08 PM CST

Title: Paralympic Bench Press Analysis

Date: 1/31/24

Content by: James Waldenberger

Present: N/A

Goals: Get some good background on existing studies done on bench pressing, review their techniques for measurement and see what needs to be changed to fit a consumer product.

Content (acquired from PubMed - search team "level barbell"): https://pubmed.ncbi.nlm.nih.gov/36560273/

- This study was done to determine if the use of inertial measurement units (IMUs) were applicable for barbell velocity monitoring
  - Found a "high spatial similarity and small differences between devices [making IMUs] suitable for different applications in barbell velocity monitoring"
- References linear position transducers and video solutions as other ways to get similar information
- Showed good reliability in determining velocity, and could possibly be used to find level imbalances
- Figure 1 shows the IMUs on either side of the barbell
  - Small attachments around the grip of the barbell that don't add too much weight
  - No cords used in their setup either
- Data was compared against a video setup with markers at each end of the barbell, and was found to be pretty accurate both ways

Conclusions/action items:

This study outlines three common ways that these bench press analyses are being done. Overall, the linear position transducers and IMUs are applicable to our project, whereas the video methods are too inefficient for what Mr. Gold envisions and would hardly provide real time feedback unless a monitor was set up.

James Waldenberger - Feb 01, 2024, 8:54 PM CST


sensors

Article

Validation of an Automatic Inertial Sensor-Based Methodology for Detailed Barbell Velocity Monitoring during Maximal Paralympic Bench Press

Download

paralympicbarbell.pdf (2.15 MB)

1/31/24 Bench Press Study

James Waldenberger - Feb 01, 2024, 11:09 PM CST

Title: Bench Press Study

Date: 1/31/24

Content by: James Waldenberger

Present: N/A

Goals: Get some good background on existing studies done on bench pressing, review their techniques for measurement and see what needs to be changed to fit a consumer product.

Content (acquired from PubMed - search term "bench press biomechanics"): https://pubmed.ncbi.nlm.nih.gov/33555823/

Disclaimer - the content in this article is not entirely applicable to our project, but there are multiple things in it that I saw and wanted to remember

- Firstly, looking at figure 1, we can see the different placements of the EMG sensors on each muscle
  - One thing to keep in mind: there will be a competition between having precise data for each muscle and cost for sensors
  - We can use this for reference if we use electrodes
- Looking down to figure 3, it shows their setup for a custom barbell that they used when testing data for the experiment
  - Force transducers on either end of the bar measure lateral & medial forces at each hand
- They have a similar setup to what Mr. Gold was envisioning, with muscle data coming in from EMG and a custom barbell
- Some adjustments to be made: less total sensors (reduce cost), more custom electronics on barbell for live rep counting, a display somewhere on the bar with rep and muscle information shown

Conclusions/action items:

This article will be a good reference for when the group gets going on the barbell. It seems unlikely that a barbell alone will be able to get everything Mr. Gold wants in regard to muscle data, more accurate EMG sensors are probably the way to go.

James Waldenberger - Feb 01, 2024, 8:54 PM CST


Original Research

Understanding Bench Press Biomechanics—The Necessity of Measuring Lateral Barbell Forces

Abstract

Introduction

Download

understanding_bench_press_biomechanics_the.3.pdf (1.01 MB)

1/31/24 Similar Patents

James Waldenberger - Feb 01, 2024, 8:51 PM CST

Title: Similar Patents

Date: 1/31/24

Content by: James Waldenberger

Present: N/A

Goals: Research patents that are doing similar things as the level barbell in order to get ideas on what to do and what not to do in the coming weeks.

Content (acquired from Google Patents - search term "rep counting barbell")**:** https://patents.google.com/patent/US11260262B2/en?q=(rep+counting+barbell)&oq=rep+counting+barbell

- Data acquisition done by two devices on either side of the barbell hooked up via cord to a platform under the person exercising.
- Various spots for the cords to attach, opening possibilities for a multitude of different exercises
- Archives data from exercise to an app on the user's phone, showing calories burned, total reps, total time of the exercise, etc.
    - With a similar setup, the levelness of the bar could also be determined
- Compact setup and collapsible bar make for easy transportation, something that we should also think about
- Applicable with lifts like deadlift and squat (possible bench press?) and various other band-pulling exercises

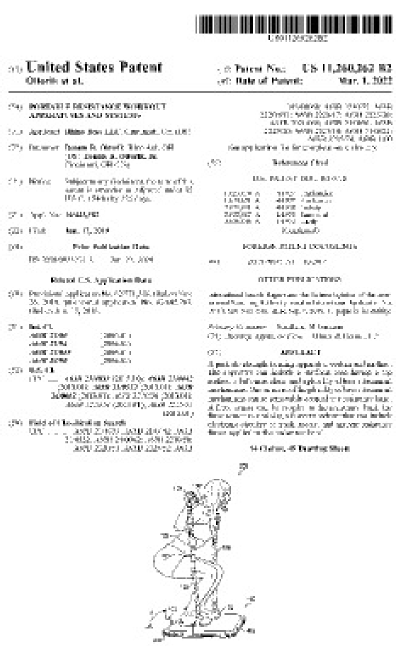
Pros: Seems relatively inexpensive and easy to set up/use, very portable

Cons: Not applicable for all types of lifts, different bands required depending on how intense the user wants a lift to be, no live feedback, board on ground is necessary (possible cumbersome)

Conclusions/action items:

I hadn't thought of using resistance bands for this project, so that is an avenue that we could use going forwards. There is an issue of where the live feedback would go on a device like this.

James Waldenberger - Jan 31, 2024, 9:23 PM CST


United States Patent
Patent No.: US 11,260,262 B2
Date of Patent: Mar. 1, 2022

[Download](#)

RepCountingBarbell.pdf (2.71 MB)

1/31/24 Weight Lifting Biometrics

James Waldenberger - Feb 02, 2024, 1:26 PM CST

Title: Weight Lifting Biometrics

Date: 1/31/24

Content by: James Waldenberger

Present: N/A

Goals: Practice searching for scholarly articles in lecture and find some good ones to read in regards to studying our weight lifting injury problem.

Content (acquired from Google Patents - search term "barbell level")**:** https://patents.google.com/patent/US20220016483A1/en?q=(barbell+level)&oq=barbell+level

For reference, Bob Gold (client) is also interested on obtaining real-time muscle biometric data during lifts. This patent shows a device that is similar in style to what Mr. Gold was talking about in that regard.

- This apparel is equipped with multiple types of sensors (ECG & EMG) to determine heart rate and muscle activity
- Sensors on deltoids, biceps, pectorals, abs, and quads
- Data compiled into an app on the wearer's phone
    - Potentially shows sets & reps, specific muscle activation, imbalance during lift, and heart rate
- No live feedback, however, user must look at phone after exercise is complete
- Main purpose is to collect data on the user's lifts and compile a workout routine that will suit them

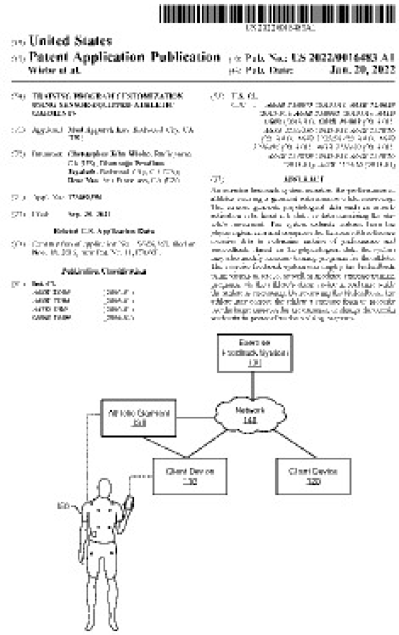
Pros: Could possible be somewhat adapted to suit our purpose of preventing injury (more research required), reusable after purchase, lots of good data on muscle usage during lifts

Cons: Potentially expensive, no live feedback, potential inaccuracy, already a patent

Conclusions/action items:

Use of ECG and EMG sensors in a set of workout clothes is an idea that I had during the first meeting with the client. It has been done before, but there is still potential to try and adapt it to our purposes. Depending on how we move forward with the project this would be something that would need to be looked into more.

James Waldenberger - Jan 31, 2024, 9:08 PM CST


United States

Patent Application Publication

Related U.S. Application Data

Publication Classification

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BiometricGarment.pdf (2.13 MB)

2/22/24 Arduino RADAR

James Waldenberger - Mar 21, 2024, 12:30 AM CDT

Title: Arduino RADAR

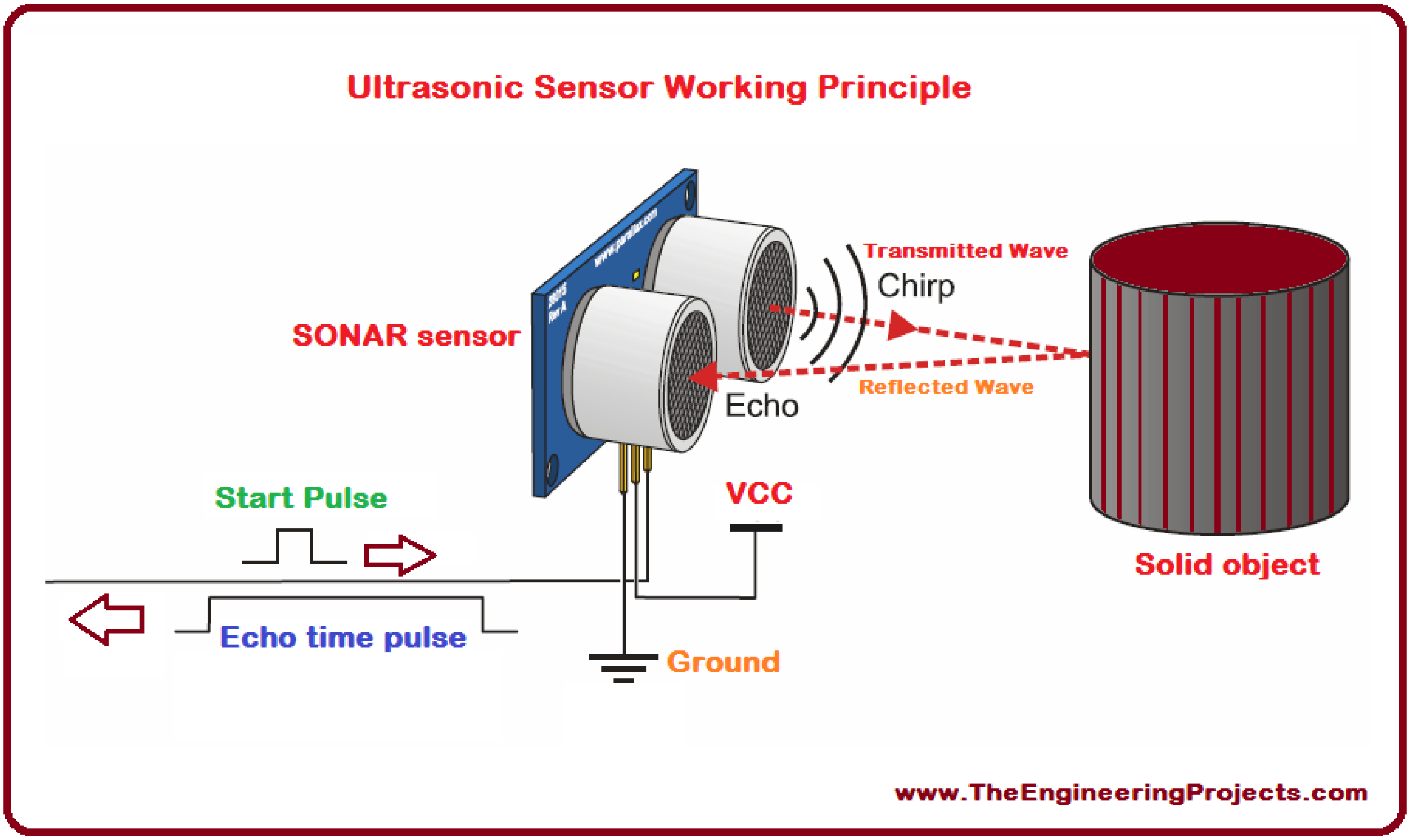
Date: 2/24/22

Content by: James Waldenberger

Present: N/A

Goals: Research the RADAR Arduino component and see how it functions in tandem with the Arduino microcontroller.

Content (Google - search term "arduino radar"): https://www.theengineeringprojects.com/2017/08/ultrasonic-sensor-arduino-interfacing.html



- Find range values for our sensor of choice, as well as measuring angle. These are important values that we should know to determine the function of the sensor
- PWM pin input gives time from echo time pulse, using calculations that will need to be determined later
- Example code:

```
// defines arduino pins numbers
const int trigPin = 12;
const int echoPin = 11;
// defines variables
long duration;
int distance;
void setup()
{
pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
pinMode(echoPin, INPUT); // Sets the echoPin as an Input
Serial.begin(9600); // Starts the serial communication
}
void loop() {
// Clears the trigPin
```

```
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
// Reads the echoPin, returns the sound wave travel time in microseconds
duration = pulseIn(echoPin, HIGH);
// Calculating the distance
distance= duration*0.034/2;
// Prints the distance on the Serial Monitor
Serial.print("Distance from the object = ");
Serial.print(distance);
Serial.println(" cm");
delay(1000);
}
```

- Refer to this code and pinout diagram for our sensor of choice in order to assemble it into prototype

Conclusions/action items:

Use example code to make a working prototype for the show and tell.

2/22/24 Materials

James Waldenberger - Mar 21, 2024, 12:36 AM CDT

Title: Materials

Date: 2/22/24

Content by: James Waldenberger

Present: N/A

Goals: Research common materials in activity equipment to see what is being used and why.

Content (Google Scholar - search term: "sweat proof clothing") https://www.jstage.jst.go.jp/article/ahs1995/14/3/14_3_141/_article/-char/ja/

also https://link.springer.com/article/10.1007/s40279-013-0047-8

- Materials to consider
    - Nylon
    - Water repellent cotton
    - Polyester mixes
    - Other synthetic materials
- These are the materials used in lots of athletic wear, but for our purposes the one we want will be the most durable out of the bunch
- For the muscle-sensor option from the design matrix, we might need to take into account more of the sweat-resistant factors of a material
- Other options from the design matrix will not need to consider this

Conclusions/action items:

Once we decide on our assured design option, more research into materials will be necessary to determine what one will fit with that design.

3/21/24 Flexible Display

James Waldenberger - Apr 30, 2024, 7

Title: Flexible Display

Date: 3/21/24

Content by: James Waldenberger

Present: N/A

Goals: Research flexible display options as outlined by Robert Gold as a design idea.

Content:

A video similar to what we were envisioning when it comes to having a flexible display: https://www.youtube.com/watch?v=NURLeeyPu2c&ab_channel=AdafruitIndustries

Amazon links (from lowest to highest quality display):

- https://www.amazon.com/2-9inch-Flexible-Display-HAT-Raspberry/dp/B07VBW3WN5
- https://www.amazon.com/wisecoco-Flexible-Display-Bendable-Controller/dp/B0CN3DLFX9/ref=asc_df_B0CN3DLFX9/?tag=hyprod-20&linkCode=df0&hvadid=693615855514&hvpos=&hvnetw=g&hvrand=3249195496201785998&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018948&hvtarg 2280588532220&psc=1&mcid=031dbfdfbabf329dbaf388973302971b&gad_source=1&gclid=CjwKCAjwrcKxBhBMEiwAIVF8rI6vFkpjjV_b4WuR7aYwGOuRXIe_fM-1sxPG3fe6Bs1CBFkuPOmQwhoCou8QAvD_BwE

There doesn't seem to be a lot of well-priced and effective options for a flexible display on the market yet. The main reason we would want a flexible display is to increase visibility from all angles and provide a bit of comfort if the barbell is resting on the user's chest. However, even the cheapest option for a screen like this is $25 and it is hardly large enough to warrant spending that muc us or for the consumer.

Conclusions/action items:

Look into more affordable options for a raspberry pi display. See what's on the market and what we'll want for a simple display for the poster presentation.

3/21/24 Other Display Options

James Waldenberger - Apr 30, 2024, 7:57 PM CDT

Title: Other Display Options

Date: 3/21/24

Content by: James Waldenberger

Present: N/A

Goals: Due to the steep price and difficulty to obtain, other screen options might be more suitable for a first-semester project as opposed to a flexible display. Figure out what display needs to be acquired in order to have an effective showing at the poster design presentation.

Content:

Amazon links for possible options:

- https://www.amazon.com/GeeekPi-Display-SSD1306-Arduino-Raspberry/dp/B0832GK5SP
- https://www.amazon.com/Display-Module-SSD1306-Du-pont-Arduino/dp/B07VDXYDVY?th=1

These options would be good for our purposes, and are about $10 cheaper and higher quality than the flexible counterparts. However, we conversed with Dr.Nimunkar and he said that we could possibly take a 4-segment display from his storage if we needed it. This would be good because we have already used this type of display before and therefore have working code for it, albeit on Arduino instead of Raspberry Pi OS.

Conclusions/action items:

Get a 4-segment display from Dr.Nimunkar ASAP and get the code working to show the user if the barbell is at an angle.

4/8/24 Pi Pico W

James Waldenberger - Apr 08, 2024, 1:26 PM CDT

Title: Pi Pico W

Date: 4/8/2024

Content by: James Waldenberger

Present: N/A

Goals: Research the Raspberry Pi Pico W (recommended by seniors at show and tell) to see if it is applicable to the project. If it is, also get a link to buy it.

Content:

Our design requires wireless transmission between radar attachments and the display attachment. The seniors at show and tell said using a Pi Pico W microcontroller would be an easy and cheap option for us.

Raspberry Pi Pico W (https://www.raspberrypi.com/documentation/microcontrollers/raspberry-pi-pico.html)

- <$10 from every seller online, good price for us
- "Raspberry Pi Pico W adds on-board single-band 2.4GHz wireless interfaces (802.11n) using the Infineon CYW43439 while retaining the Pico form factor."
    - Bluetooth 5.2 support as well, in case there are issues with Wifi
- Micro USB port for power, runs on 1.8V-5.5V

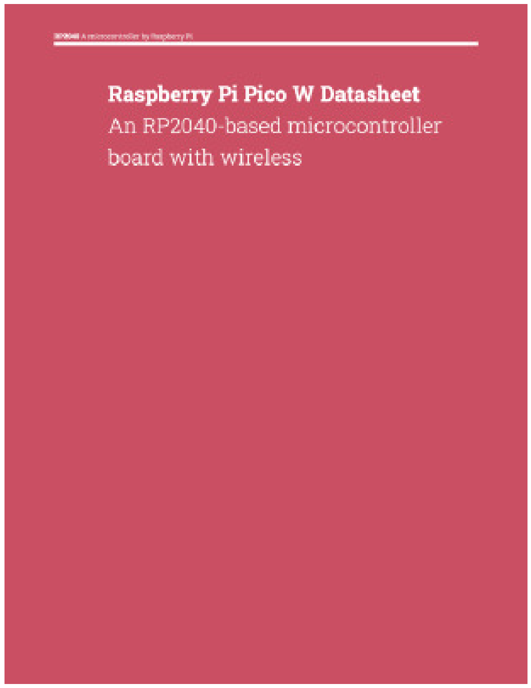
We will end up going with this microcontroller for the project, see datasheet attached below

Link to buy: https://www.raspberrypi.com/products/raspberry-pi-pico/

Conclusions/action items:

Send the request to Bob to buy the microcontrollers. We also need to find power supplies to power the wireless attachments and middle attachment.

James Waldenberger - Apr 08, 2024, 1:26 PM CDT


Raspberry Pi Pico W Datasheet
An RP2040-based microcontroller board with wireless

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pico-w-datasheet.pdf (19.8 MB)

4/8/24 Power Supplies

James Waldenberger - Apr 29, 2024, 10:17 PM CDT

Title: Power Supplies

Date: 4/8/2024

Content by: James Waldenberger

Present: N/A

Goals: Figure out what needs to be purchased in order to supply power to each of the circuits used in our design.

Content:

2 Different circuits: Sensor attachment (Raspberry Pi Pico W) and screen attachment (Raspberry Pi 4)

Sensor attachment:

- Pico W has operating conditions from 1.8-5.5V, 25-300mA (depending on power outputs)
- Ultrasonic sensor has operating conditions from 2.5-5.5V, 2.0mA
- Relatively low voltages and amperages don't require an expensive power supply solution, batteries should suffice
- 3 AA batteries will provide a long charge for the electronics, and be in the voltage range ~4.5V

Screen attachment:

- Pi 4 Model B has operating conditions from 1.8-5.5V, 800mA (in base conditions, so likely more)
- Pi 4 has a spot for a power connection on the circuitry, via USB-C connection
- Use of a power brick is recommended, so that's what we'll go with

Conclusions/action items:

Moving forward, we need to find 2 battery packs with wire connections, and a power supply brick with USB-C connection to order.

1/31/24 Annotated Bibliography

James Waldenberger - Apr 30, 2024, 7:58 PM CDT

Title: Annotated Bibliography

Date: 1/31/24

Content by: James Waldenberger

Present: N/A

Goals: Cite each source used in my research notes folder and provide a small annotation as to why said source is being used.

Content:

[1] J.-K. Davis and P. A. Bishop, "Impact of Clothing on Exercise in the Heat," *Sports Med*, vol. 43, no. 8, pp. 695–706, Aug. 2013, doi: 10.1007/s40279-013-0047-8.

Compares synthetic materials to natural ones used as clothing for bouts of exercise in the heat. Concluded that there is no significant difference between the two types of materials in their ability to thermally conduct, as well as there being no significant difference in subject comfort.

[2] D. R. Oltorik and D. R. O. JR, "Portable resistance workout apparatuses and systems," US11260262B2, Mar. 01, 2022 Accessed: Jan. 31, 2024. [Online]. Available: https://patents.google.com/patent/US11260262B2/en?q=(rep+counting+barbell)&oq=rep+counting+barbell

A resistance band based system with devices that attach to said bands and monitor barbell exercises (or other band exercises). Uses a platform to hook the band to, and each part is collapsible/modular enough so that the entire setup can fit inside a case and be transported with ease.

[3] Y. Hirabayashi-Yamashita, C. Hayashi, R. Imamura, and H. Tokura, "Sweat Responses to Pesticide-Proof Clothing Influenced by Textile Materials," *Applied Human Science*, vol. 14, no. 3, pp. 141–147, 1995, doi: 10.2114/ahs.14.141.

Research done on different materials and their response/triggering of sweat from the human body when worn as clothing. Concluded that a water proof finishing of nylon material improves subject comfort and reduces possibility of heat strain.

[4] C. J. Wiebe, D. P. Jayalath, and R. Yao, "Training program customization using sensor-equipped athletic garments," US20220016483A1, Jan. 20, 2022 Accessed: Jan. 31, 2024. [Online]. Available:

https://patents.google.com/patent/US20220016483A1/en?q=(barbell+level)&oq=barbell+level.

A similar idea to something that I had thought of during a meeting with Mr. Gold, where he outlined his ideas for possibly sensing muscle activity during a lift and monitoring risk of failure/injury in real time. This patent outlines the author's idea to connect muscle data to a phone app to track different biometrics during exercise and create a personalized exercise plan for the user.

[5] syedzainnasir, "Ultrasonic Sensor Arduino Interfacing - The Engineering Projects." Accessed: Mar. 21, 2024. [Online]. Available: https://www.theengineeringprojects.com/2017/08/ultrasonic-sensor-arduino-interfacing.html

Describes the working mechanism behind the Arduino ultrasonic sensor and provides images/examples of its use cases along with code and circuit diagrams using said sensor. Refer back to this source if there is difficulty in setting up the sensor, especially with the pulse width input from the echo pulse.

[6] L. Mausehund, A. Werkhausen, J. Bartsch, and T. Krosshaug, "Understanding Bench Press Biomechanics—The Necessity of Measuring Lateral Barbell Forces," *The Journal of Strength & Conditioning Research*, vol. 36, no. 10, p. 2685, Oct. 2022, doi: 10.1519/JSC.0000000000003948.

Shows ideal EMG sensor setup on upper body muscles for most accurate data collection. Schematic of their custom barbell is also provided, which shows their use of force transducers to get force data for their study. Use this article for later reference.

[7] L. Rum, T. Sciarra, N. Balletti, A. Lazich, and E. Bergamini, "Validation of an Automatic Inertial Sensor-Based Methodology for Detailed Barbell Velocity Monitoring during Maximal Paralympic Bench Press," *Sensors (Basel)*, vol. 22, no. 24, p. 9904, Dec. 2022,

doi: 10.3390/s22249904.

A study done on paralympic bodybuilders doing a bench press. Compared video of their 1-rep-max lifts to an inertial measurement unit device attached to the barbell. Velocity measurements were found to be very similar between the two methods, and the authors conclude that the IMUs would be a good fit for further research on the subject. This study outlines multiple different ways of measuring barbell position, and provides methods to do so.

Conclusions/action items:

Continue to update annotated bibliography as more sources are being used.

2/15/24 Design Sketches

James Waldenberger - Feb 15, 2024, 9:30 PM CST

Title: Design Sketches

Date: 2/5/24

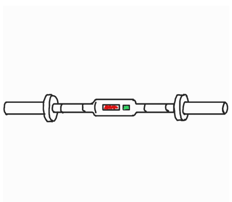
Content by: James Waldenberger

Present: N/A

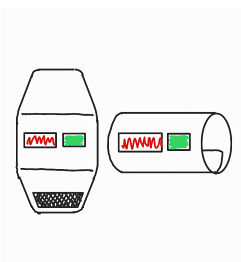
Goals: Sketch design ideas for use in the design matrix. Show off important features and silhouettes for the product.

Content:

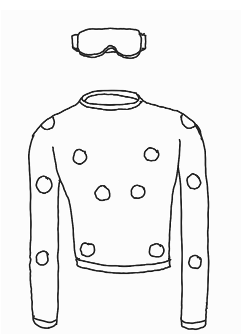
Full Barbell: Make an entire barbell with a display in the middle of the bar, so that the user can see if their lift is level and their set/rep count



Barbell Attachment: Similar to the full barbell, but the display would be attachable to any regular barbell



Suit & VR: EMG and IMU sensor embedded into a shirt that track muscle activity and limb movement, then upload that data to an app on a VR headset, showing the user their performance data and notify them of any form imbalances



Conclusions/action items:

Add labels for use in the preliminary presentation and choose which design we'll be using moving forward with the design matrix.

Loading [MathJax]/extensions/Safe.js

3/19/24 Updated Design Sketches (Dimensioned - From Protocol)

James Waldenberger - Mar 19, 2024, 8:45 PM CDT

Title: Updated Design Sketches

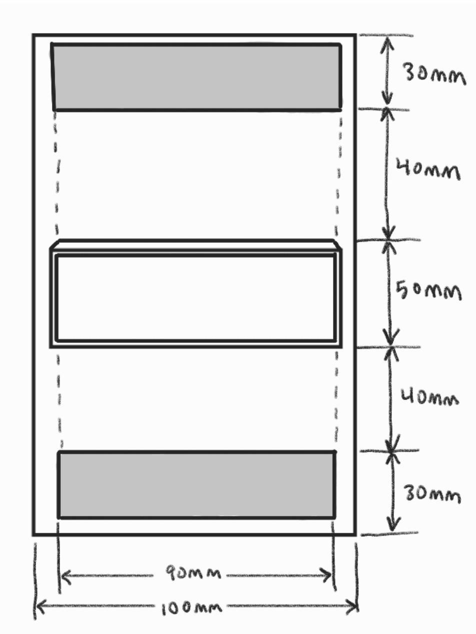
Date: 3/19/2024

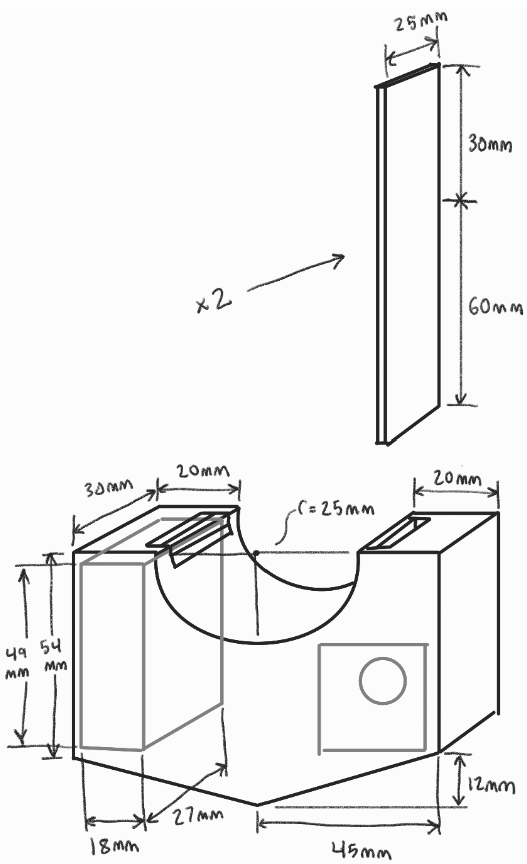
Content by: James Waldenberger

Present: N/A

Goals: Update design sketches and add dimensions to write a fabrication protocol. Use said protocol to make a design prototype for the show and tell.

Content:





Conclusions/action items:

Use the designs above to create a prototype for use in the show and tell. Make note of any dimension adjustments that need to change on the final prototype.

4/19/24 Potential Wi-fi Code

James Waldenberger - Apr 29, 2024, 10:02 PM CDT

Title: Potential Wi-fi Code

Date: 4/19/24

Content by: James Waldenberger

Present: N/A

Goals: Create code that will function to wirelessly connect the Raspberry Pi's and allow for data transmission to be displayed by the screen attachment. This was attempted with Bluetooth but didn't work as intended, so a solution using Wi-fi is being attempted here.

Content:

#Code for the Raspberry Pi Pico W:

```
import network

import socket

from time import sleep

import machine


ssid = 'UWNet'

#password = no password because it's an open network?

portnum = 2222 #figure out what port number to use

bufferSize = 1024


def connect ():

    wlan = network.WLAN(network.STA_IF)

    wlan.active(True)

    wlan.connect(ssid)

    while wlan.isconnected() == False:

        print('Waiting for connection...')

        sleep(1)

    ip = wlan.ifconfig()[0]

    print(f'Connected on {ip}')

    return ip


def open_socket(ip):

    address = (ip, portnum)

    connection = socket.socket()

    connection.bind(address)

    connection.listen(1)

    print(connection)
```

```
    return connection


def send_msg(ip,portnum,msg):
    bytes = msg.encode('utf-8')
    RPIsocket = socket.socket(socket.AF_INET,socket.SOCK_DGRAM)
    RPIsocket.bind((ip,portnum))
    print('Server is up and listening...')
    inmsg, address = RPIsocket.recvfrom(bufferSize)
    inmsg = inmsg.decode('utf-8')
    print(inmsg)
    print('Incoming address:', address[0])
    RPIsocket.sendto(bytes,address)


try:
    ip = connect()
    connection = open_socket(ip)
    msg = 'testing from Pico'
    send_msg(ip, portnum, msg)


except KeyboardInterrupt:
    machine.reset()
```

#Code for the Raspberry Pi 4 Model B:

```
import socket



msg = 'Test from Pi4'
bytes = msg.encode('utf-8')
serverAddress = ('127.0.0.1',2222)
bufferSize = 1024
Client = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
Client.sendto(bytes,serverAddress)
print('Data sent. Awaiting response from Pico.')
data,address = Client.recvfrom(bufferSize)
data = data.decode('utf-8')
print('Data from server:', data)
```

```
print('Server IP:', address[0])

print('Server port:', address[1])
```

Conclusions/action items:

Unfortunately there were also issues with implementing the Wi-fi to allow for wireless communication. The cause of this problem is thought to be the way that UWNet functions, as it is not a server with a single IP address that can easily be used in this manner. I also attempted to create an ad-hoc connection from the Raspberry Pi 4 Model B, but the communication never managed to work (the IP addresses didn't seem to line up, although I could technically see the network through my phone's settings app).

4/21/24 Pico ADC Input Code

James Waldenberger - Apr 29, 2024, 10:06 PM CDT

Title: Pico ADC Input Code

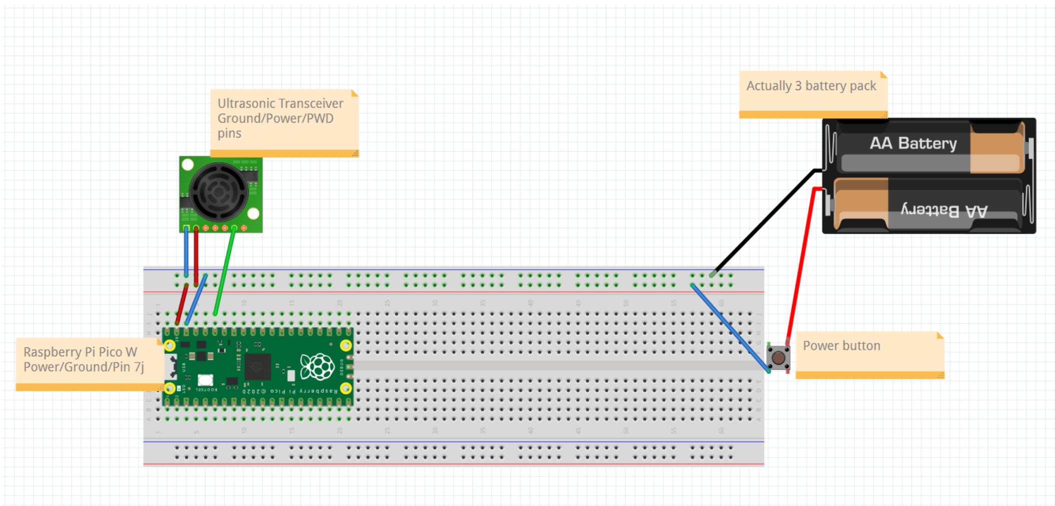
Date: 4/20/24

Content by: James Waldenberger

Present: N/A

Goals: Create some code that allows for reading of the ultrasonic sensor as an ADC input, while simultaneously testing the power supply on the circuit.

Content:



The circuit was set up according to the model made by Kaden

Code is as follows (for the simple test):

```
import machine
from machine import Pin, Timer, ADC
import utime

led = machine.Pin("LED", machine.Pin.OUT)
led.on() #turn LED on to show that Pico is on and code is running

analog_value = ADC(Pin(26))

while True:
    reading = analog_value.read_u16()
    print("ADC: ",reading)
    V = reading*(3.3/65535)
    print("Voltage: ", V)
```

```
    utime.sleep(0.2)
```

Conclusions/action items:

The test was a success. The code was able to be run and get voltage values based on the distance from the sensor to an obstructing object. The power supply also functioned to power both the Raspberry Pi Pico W and ultrasonic sensor simultaneously, so there are no issues there.

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

John Puccinelli - Nov 03, 2014, 3:20 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: