Chika Eke

User Experience Researcher & Engineer

Selected Work

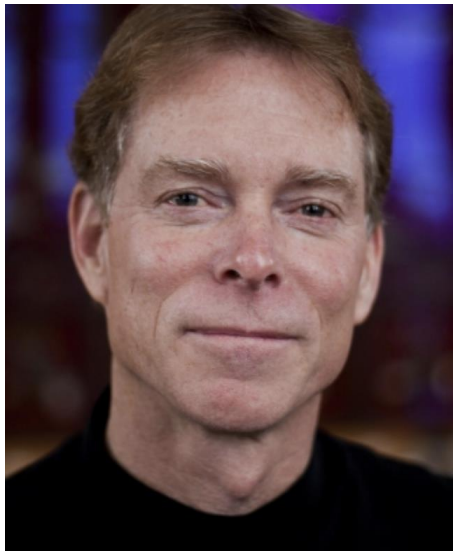
Defining Human Agility

- Why?
  - Demonstrates design process & quantitative methods.

Team

Chika Eke
Graduate Research Assistant

Leia Stirling, PhD
Principal Investigator (MIT)



Noel Perkins, PhD
Principal Investigator (UM)

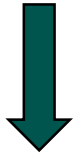
Alyssa Mendoza
Systems Programmer

Introduction

- **Agility** (ability to change speed or direction) performance analysis is typically time-based.
  - No indication of underlying factors aiding or limiting performance.
- **Objective:** Determine how experts in multiple fields evaluate agility to better understand which aspects of agility technique can be used to inform soldier training & rehabilitation.

Research Questions

How do experts working in athletic, clinical, and military environments evaluate agility performance?



What metrics distinguish levels of agility performance?

How can we create compelling summaries of performance for evaluators?

Potential Users & Applications

Clinician

Rehabilitation Tracking

Patient

Coach

Performance Training

Athlete

Military Officer

Performance Training

Recruit

Methods

- I utilized the **Double Diamond** framework:

1. Discover Issue

Participant Recruitment

Survey Design

2. Define Issue

Coding

3. Develop Solution

Metric Development

Data Analysis

UI Development

4. Deliver Solution

Discover Issue

1. Discover Issue
Participant Recruitment
Survey Design

2. Define Issue
Coding

3. Develop Solution
Metric Development
Data Analysis
UI Development

4. Deliver Solution

Participant Recruitment

- I **recruited** 33 participants from a variety of disciplines that value agility in order to better understand how they evaluate agility performance:

.

Participants

33 adults (age 30 ±9 years; 16 female)

Athletic (n=8)

Military (n= 8)

GROUPS

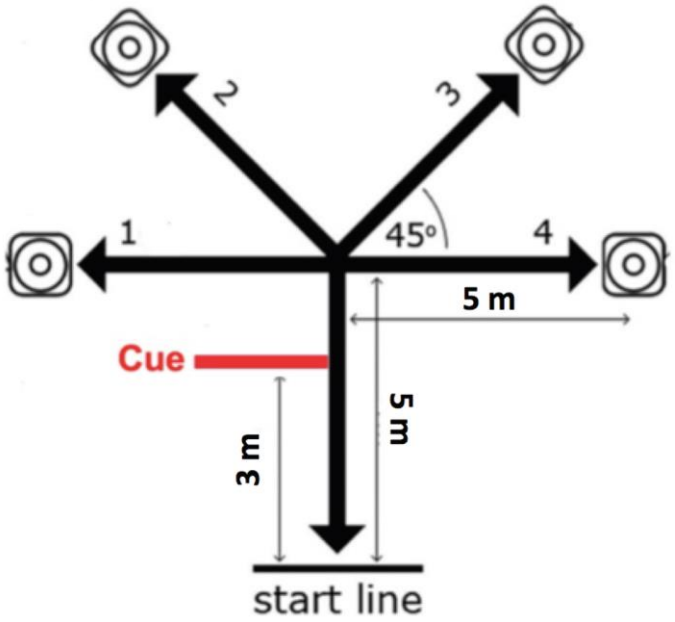
Clinical (n= 7)

Novice (n=10)

Survey Design

- I designed a **Survey** which guided participants through the scoring of 16 athletes completing a reactive agility course.
- Scores and explanations were collected for a total of 32 videos, presented in a randomized order.

.



	1	2	3	4	5	6	7	
Not Agile	○	○	○	○	○	○	○	Highly Agile

Define Issue

1. Discover Issue

Participant Recruitment

Survey Design

2. Define Issue

Coding

3. Develop Solution

Metric Development

Data Analysis

UI Development

4. Deliver Solution

Coding

- Similar terms and phrases from survey explanations were combined and a **Coding** scheme was developed.

Coding

- The final key terms were organized based on the **Coding** scheme and listed by frequency of occurrence in survey responses.

Term	Example Phrase	Frequency
speed	quickness, foot speed and time through the course	30
change direction	cutting, pivoting	24
efficient path	arcing paths, distance from cone on turns	23
reaction time	good reflexes, responds to commands in timely manner	21
body alignment	lowering center of gravity in and out of numbered breakpoints, bends well at the knees giving her sharpness changing direction	20
acceleration	quick starts and stops, acceleration out of turns	13
foot contacts	unnecessary steps before breakpoints, double footed turns, long foot contacts	13
arm motion	she is not using her arms fully, can use arms more to pump	11
smooth	very smooth runner, fluid movements	7
coordination	disjointed, legs trunk and arms all coordinated in the position changes	6
stride	long strides and at a good speed, shorter stride length and accurate change of direction	6

CU Eke, LA Stirling. Effect of Rater Expertise on Subjective Agility Assessment. International Conference on Applied Human Factors and Ergonomics (2017)

Develop Solution

1. Discover Issue

Participant Recruitment

Survey Design

2. Define Issue

Coding

3. Develop Solution

Metric Development

Data Analysis

UI Development

4. Deliver Solution

Metric Development

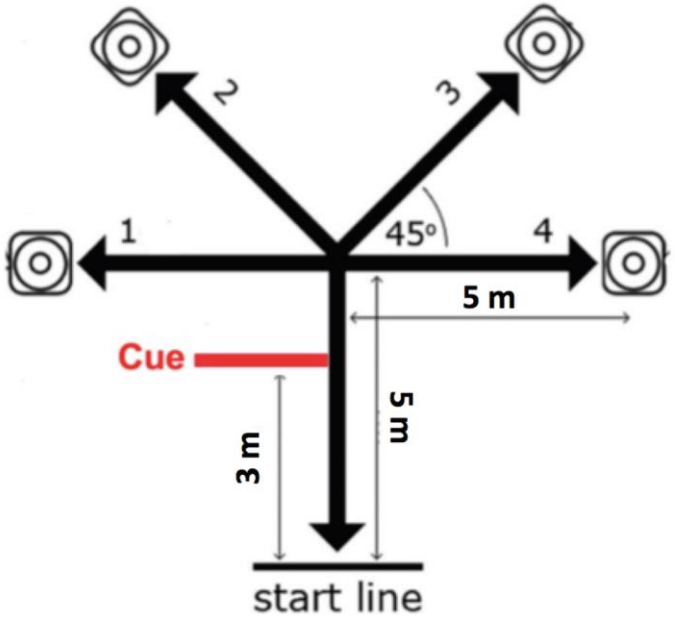
- Key terms identified through Coding inspired the creation of **biomechanical metrics**, measurable using data from athlete-worn wearable sensors.

Metric Name	Equation/Variable	Description	Expert Term
Normalized number of foot contacts	$\frac{n_{contacts}}{height}$	Number of heel-strikes and toe-offs detected from acceleration, angular velocity, and time from a foot-mounted IMU. Normalized by participant height.	Foot contacts, efficient path
Stride length variance	$\sigma^2{}_{SL}$	Variance in stride lengths defined by distance between consecutive heel-strikes	Stride, foot contacts
Arm swing variance	$\sigma^2{}_{AS}$	Variance in raw angular velocity magnitude obtained from forearm IMU. IMU worn like wrist watch	Arm motion
Mean normalized stride frequency	$NSD = \frac{SD}{\sqrt{\frac{height}{9.81}}}$ $NSF = \frac{1}{NSD}$	Unit-less quantity calculated for each stride using stride duration normalized (NSD) by participant height.	Speed
Effective body rotations	$\frac{\left(\begin{matrix}\angle\, heading_{start} \\ -\angle\, heading_{end}\end{matrix}\right)}{360}$	Difference between torso heading angle at the start and end of the trial. Result divided by 360 to convert from degrees to number of rotations.	Change direction, efficient path

CU Eke, SM Cain, LA Stirling. Strategy quantification using body worn inertial sensors in a reactive agility task. Journal of Biomechanics (2017)

Data Analysis

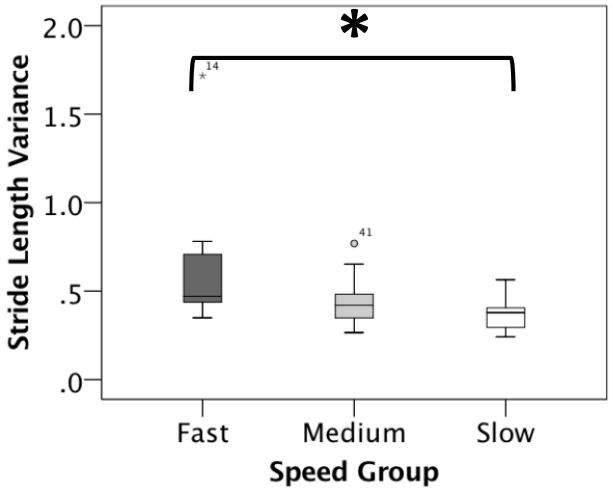
- Metric values were calculated using wearable sensor data, gathered from a pilot study which involved 18 athletes performing a reactive agility task.

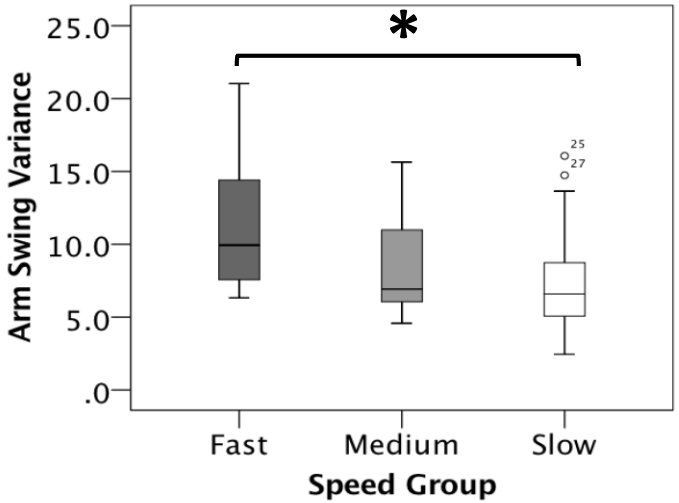


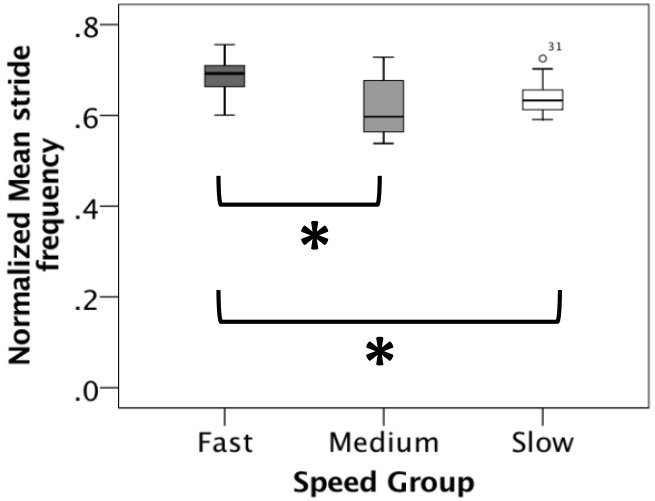
CU Eke, SM Cain, LA Stirling. Strategy quantification using body worn inertial sensors in a reactive agility task. Journal of Biomechanics (2017)

Data Analysis

- Each **biomechanical metric** was selected for its ability to distinguish between athletes stratified in fast, medium, and slow speed groups.
- The asterisks (*) represent pair-wise comparison results with p<.05.



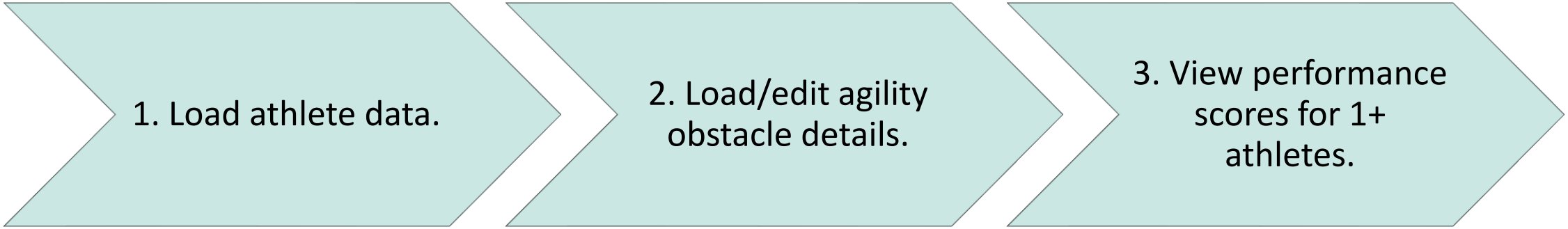




CU Eke, SM Cain, LA Stirling. Strategy quantification using body worn inertial sensors in a reactive agility task. Journal of Biomechanics (2017)

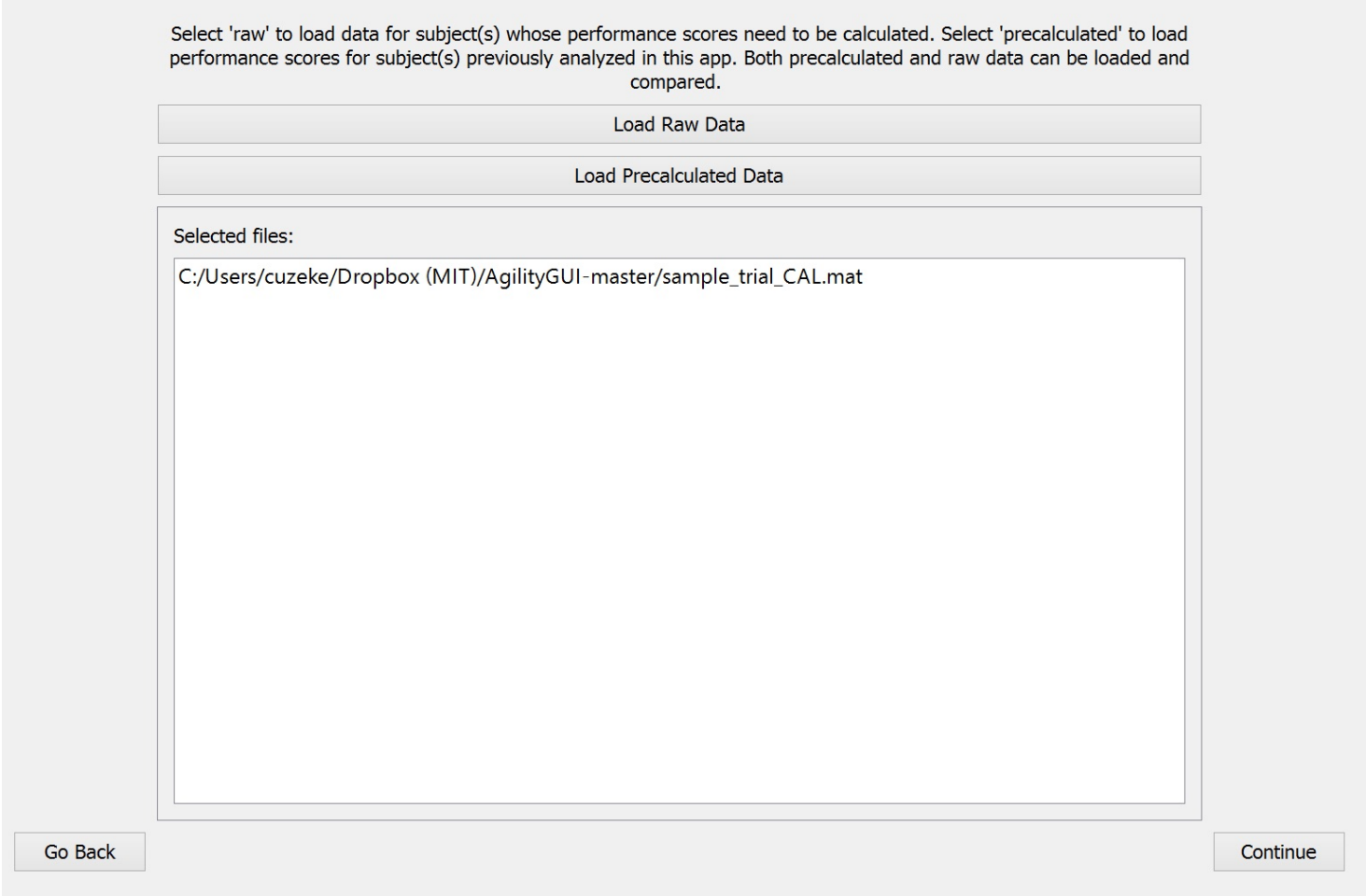
User Interface Development

- The biomechanical metrics found to distinguish between athlete speed groups were incorporated in a **graphical user interface** for reporting athlete performance.
- The interface was designed to allow an evaluator to complete the following core tasks:



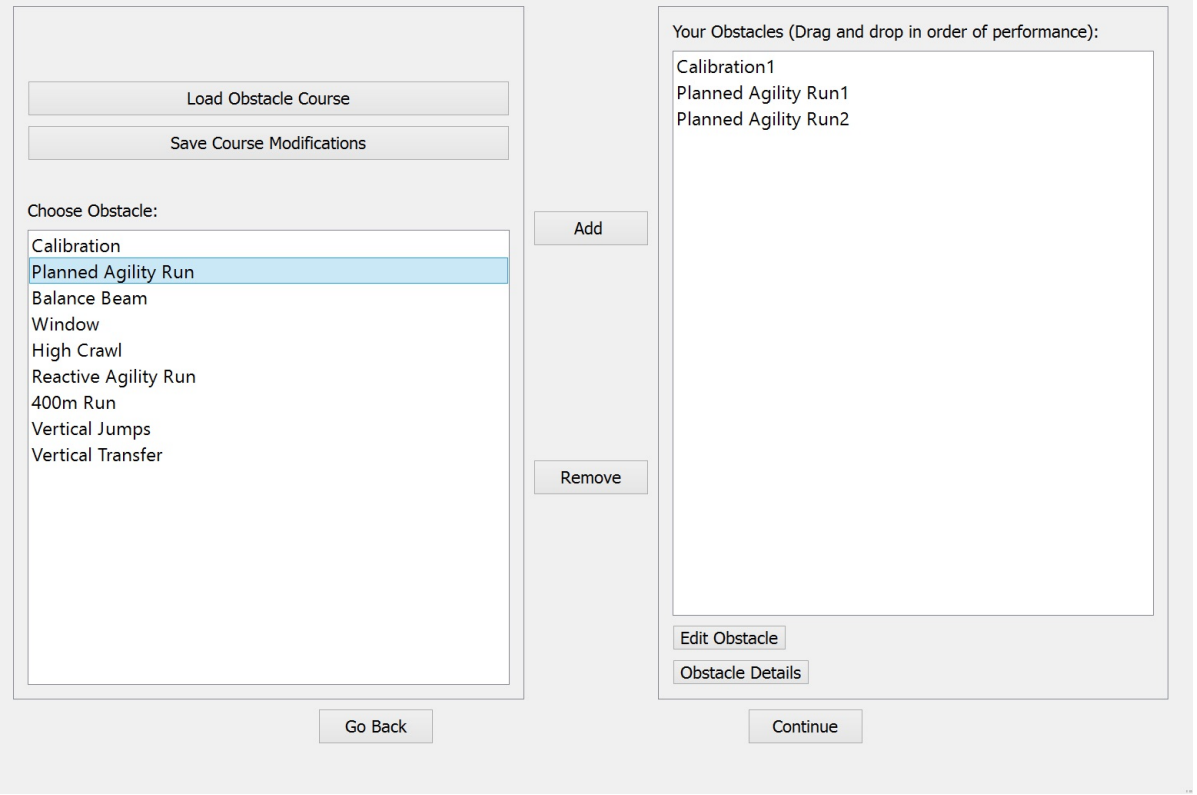
User Interface Development

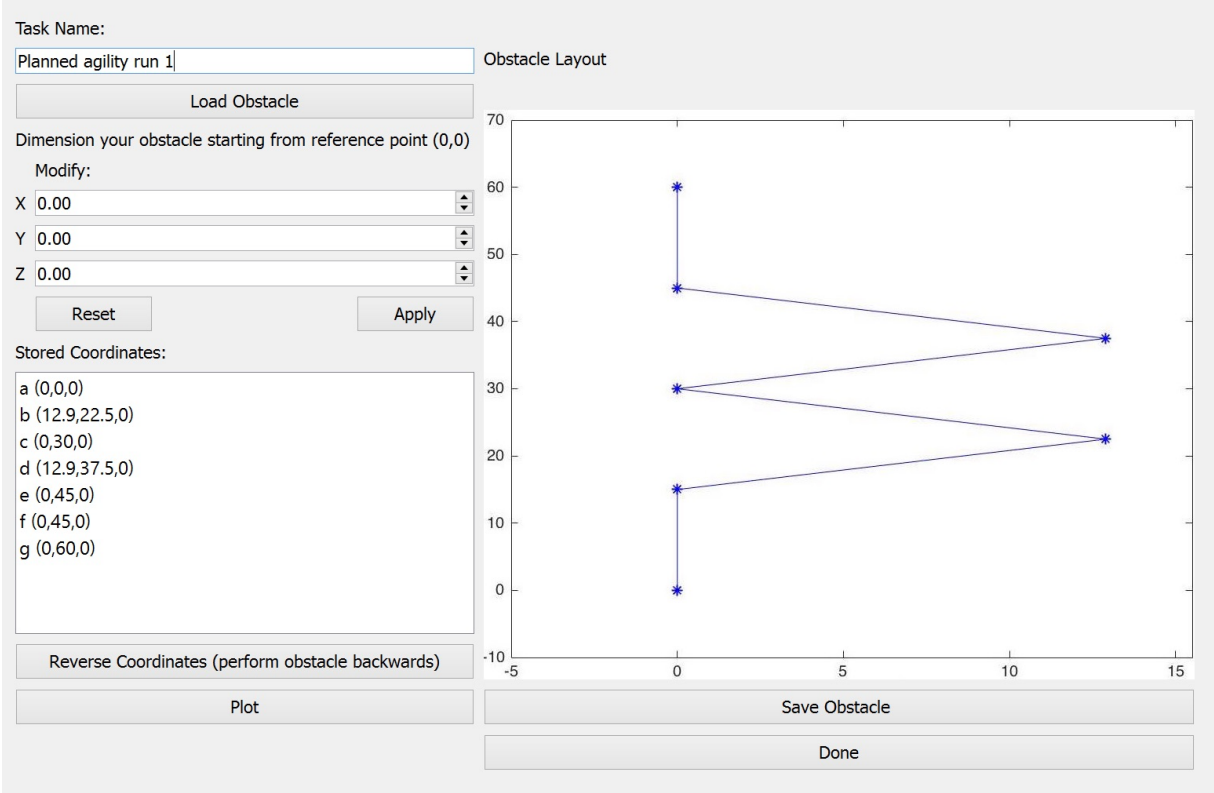
Task 1: Load athlete data.



User Interface Development

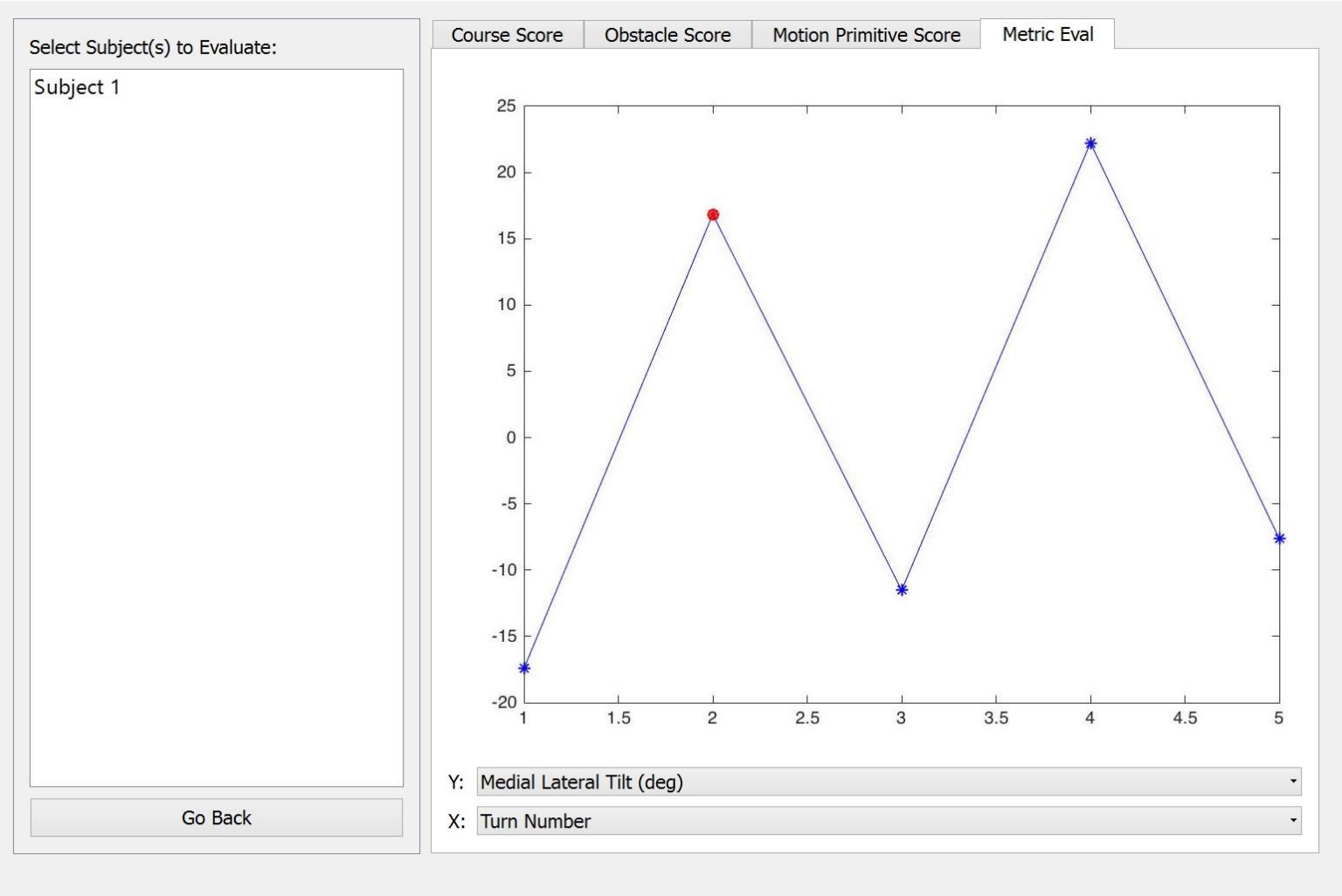
Task 2: Load and edit agility obstacle details.





User Interface Development

Task 3. View performance scores for 1 or more athletes.



User Interface Testing

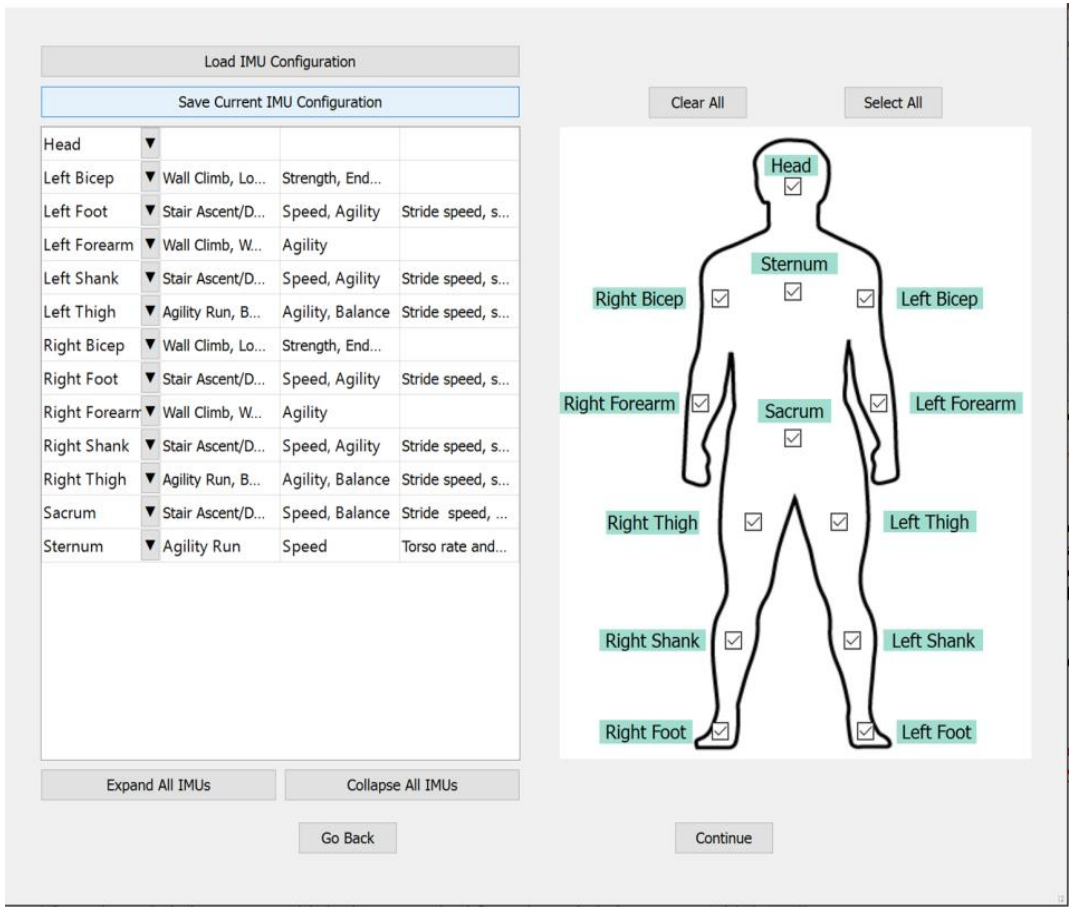
- A prototype was provided to U.S. Army Natick Soldier Research Center for remote **testing,** to evaluate the usability of each step involved in the core tasks.

Key Findings

#	Core Task	Issues Faced	Recommendations
1	Load athlete data files.	User encountered errors when selecting incorrect file format.	Only allow users to upload supported formats.
2	Load and edit agility obstacle details.	No instruction provided for sensors required for obstacle evaluation.	Addition of sensor map and selection page by obstacle type.
3	View performance scores for 1 or more athletes.	Too many tabs to sort through to find general performance overview.	Redesign in report card format, with link to details for metric breakdown (expert users).

User Interface Improvements

Recommendation
Addition of sensor map and selection page by obstacle type.

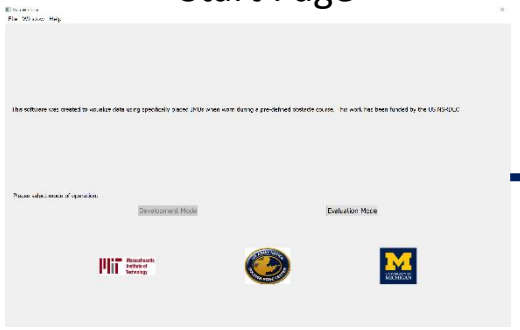


User Interface Improvements

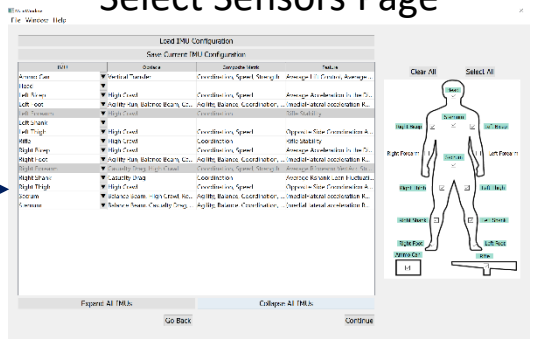
Recommendation
Redesign in report card format, with link to details for metric breakdown (expert users).

User Interface Flow

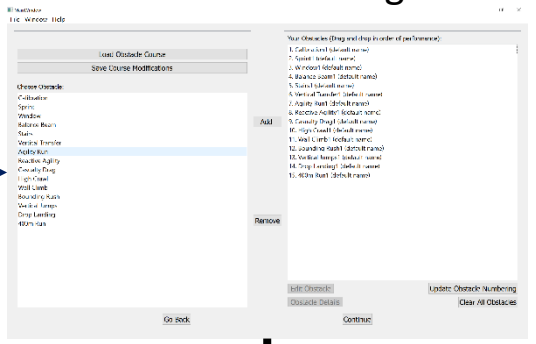
Start Page

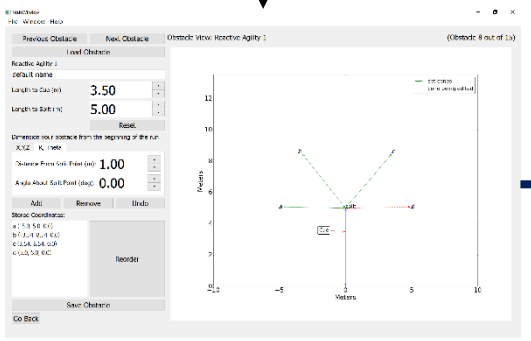


Select Sensors Page

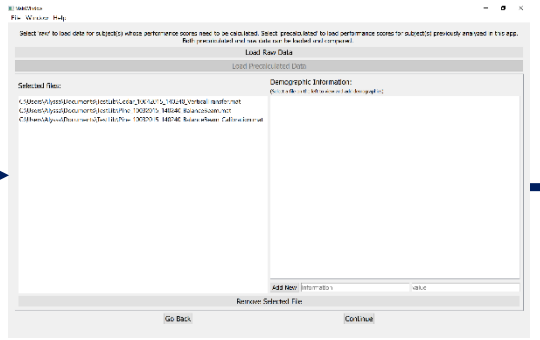


Define Course Page

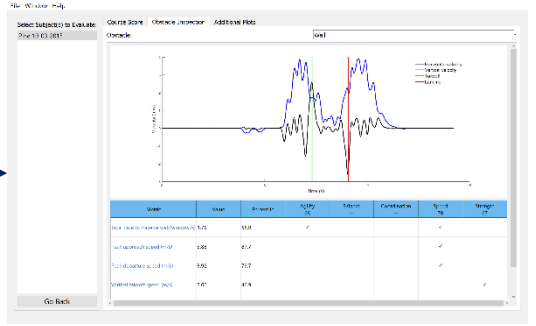




Edit Obstacle Page
(optional)



Load Data Page



Results Page

Deliver Solution

1. Discover Issue

Participant Recruitment

Survey Design

2. Define Issue

Coding

3. Develop Solution

Metric Development

Data Analysis

UI Development

4. Deliver Solution

Conclusion

- Expert decision-making is guided by technique-based metrics in addition to speed-based metrics.
- Expert qualitative terms can be used to define quantitative agility metrics.
- Agility metrics can be calculated using wearable sensors and presented as a performance summary.

Conclusion

Lessons Learned: Survey

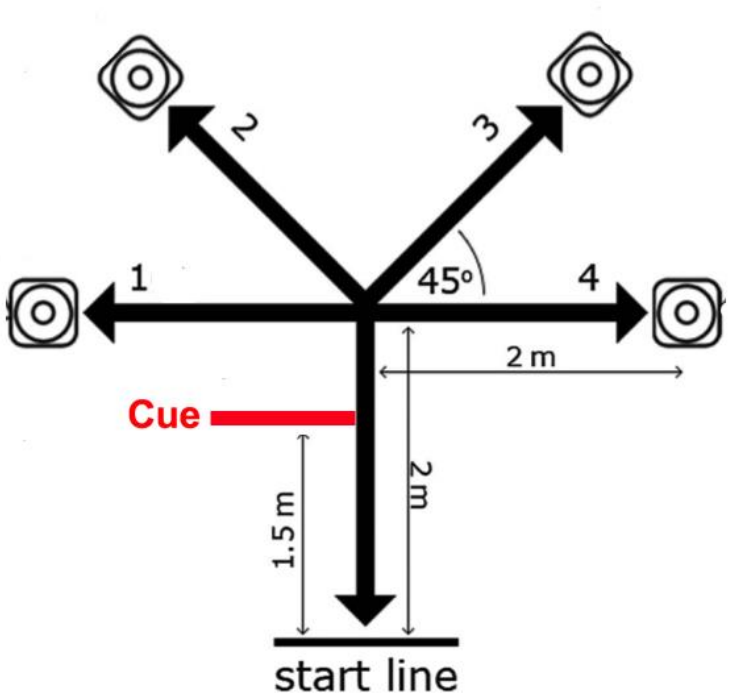
- ✓ Accommodation of specializations within evaluator groups.
- ✓ Addition of pre-data collection videos for gauging skillset.

	1	2	3	4	5	6	7	
Not Agile	○	○	○	○	○	○	○	Highly Agile

Conclusion

Lessons Learned: Metric Development

- ✓ Prioritizing raw sensor data to avoid drift error.
- ✓ Consideration of hand/food dominance.



Conclusion

Lessons Learned: User Interface

- ✓ Greater use of low fidelity prototypes.
- ✓ Inclusion of more novice users.
- ✓ Incorporation of moderated remote or in-person testing.

Future Work

- Evaluate additional areas of performance (balance, endurance, etc.).
- Explore the possibility of a ‘development mode’ for the GUI which allows the creation of new course geometries.
- Testing with additional user groups (athletic, clinical).