Team D3 - WoodWindMania

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Add your 12 slides after this slide… [remember, 12 min talk + 3 min Q/A]

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Make sure to cover: (refer to the Final Presentation Guidance):

- Use Case / Application and Primary (Quantitative) Requirements (i.e. a reminder from prior presentations)
- Solution Approach – a reminder (include updates from Design Review presentation if changed)
  - E.g. block diagram(s), flow chart(s), schematic(s)
- System Implementation – your complete solution
  - E.g., pictures, screenshots, video (make sure that there is CMU access to play any media)
- Testing, Verification and Validation – with quantitative metrics and target values to compare with experiment
  - What tests did you run ? How many tests ? What were the results ?
  - Graphs, tables, quantitative results (compare with the metric targets & ultimately use-case requirements)
- Project Management – tasks, division of labor, and schedule
- Lessons Learned

Consider that this slide already works as a introduction slide so use your first slide wisely (i.e. feel free to delete guidance text)

Use Case

- **Problem**: Learning woodwind instruments has a high cost associated with it and may not be practical to do in most environments
    - Lessons plus Instrument, can cost around $1000
    - Not beginner friendly
- **Solution**: A digital woodwind learning tool that allows users to learn fingerings on a realistic woodwind controller, in this case, a flute
- **Areas**: Hardware Design & Software Systems

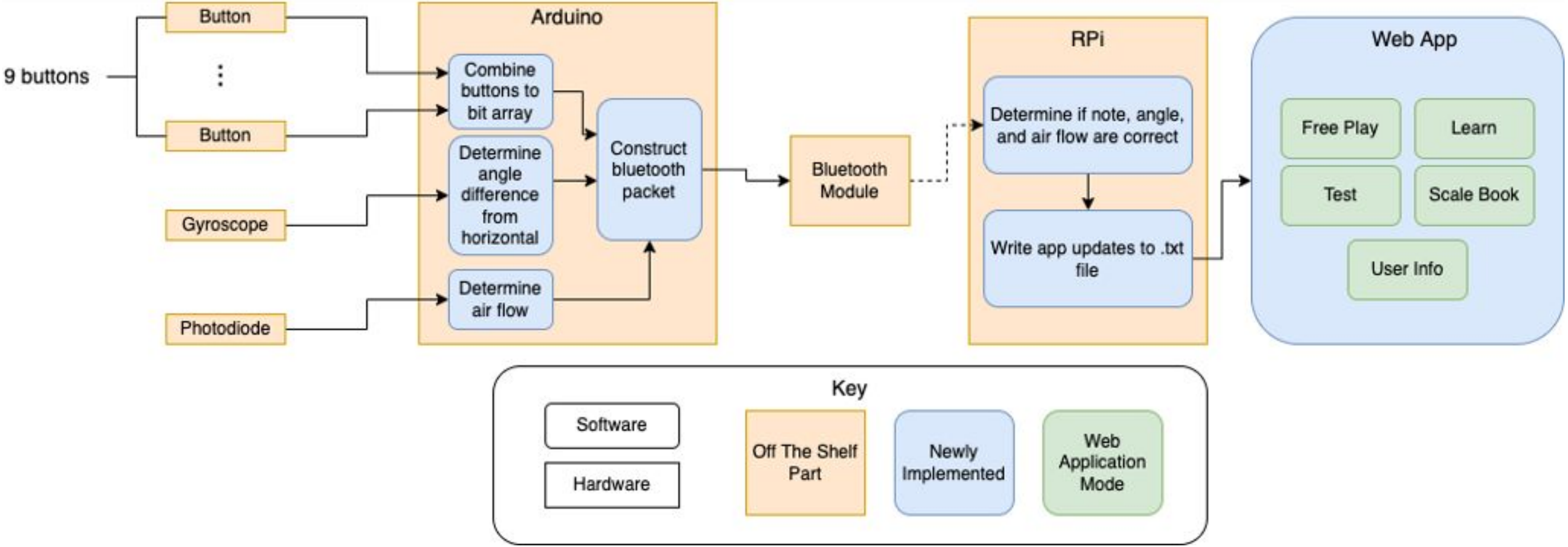
WoodWindmania

musical learning starts here

Requirements

- **User Experience**
  - Comparison to real instrument
    - Physical dimensions: 1.3lbs, 26”x1”
    - User satisfaction: 4/5
  - Beginner friendly
  - Portability
- **Accuracy**
  - Note feedback, orientation feedback, breath control feedback >= 90%
- **Speed**
  - Latency <= 500ms

Solution Approach



Complete Solution

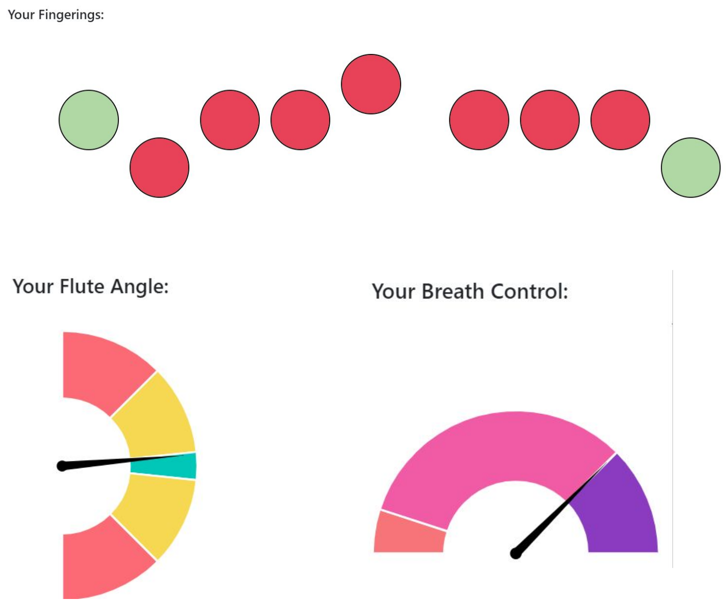
- **Physical controller**
  - 26” PVC pipe
  - 9 push buttons to detect notes
  - Breath sensor to detect between high and low octave
    - Obstacle detection using LED, photodiode, and a piece of latex to obstruct light
  - Arduino Nano 33 BLE for angle detection and bluetooth communication
  - 9V battery

Complete Solution

- **Raspberry Pi**
  - Data from controller sent via BLE to Pi
    - Connection stable from across the room
  - Pi determines note, plays the correct flute sound off of SonicPi
  - Writes buttons pressed, angle from horizontal, and breath sensor value to text file for web app to read

Complete Solution

- **Web Application**
  - Django (Python based web framework) running locally
  - RPi continually writes the flute controller data to a text file
  - The controller in MVC reads and interprets the text file
  - Web app will update with new values on a constant interval



Testing and Verification

Requirement	Metric	Testing Strategy
Accurate Feedback	Note, orientation, breath control feedback >= 90% accuracy	Give correct/incorrect notes/orientations and determine feedback Use correct/incorrect breath control, comparing to an actual flute
Speed	<= 500ms	Record bluetooth latency and web app latency separately
User Experience	1.3lbs, 26”x1” 80% user satisfaction	Measure weight, width, length Survey beginners on user experience

Testing and Verification

- **Accuracy**
  - Note feedback
    - Give correct and incorrect note fingerings
    - Average accuracy over 10 trials for each note in a scale
  - Orientation feedback
    - Use a level to test 5 degrees away from the horizontal in both directions
    - Average difference over the 10 trials
  - Breath control feedback
    - Blow soft/hard enough to play a lower/higher octave on a flute into the controller
    - Average accuracy over 10 trials

Requirement	Metric	Result
Note feedback	>= 90%	100%
Orientation feedback	>= 90%	TBD
Breath control feedback	>= 90%	TBD

Testing and Verification

- **Speed**
  - Ignore latency from sensors to Arduino, focus on Bluetooth and web app latency
  - Bluetooth latency
    - RPi sends data to the Arduino, the Arduino responds right back
    - Average the latency over 10 trials
  - Web app latency
    - RPi writes the current time in the text file
    - Average the latency over 100 trials

Requirement	Metric	Result
Bluetooth Latency	<= 100ms	96.95ms
Web App Latency	<= 400ms	269ms

Testing and Verification

- **User Experience**
  - Dimensions
    - Measure length, width, and weight of device
  - User satisfaction
    - Survey 10 beginners
    - Questions, rating from 1-5:
      - Comparison to a real flute
      - Comfort of pressing buttons
      - Comfort of breath control
      - Overall comfort

Requirement	Metric	Result
Length	26”	29” with breadboard
Width	1”	1 ⅜”
Weight	1.3lbs	TBD
User satisfaction	4/5	TBD

Trade-Offs

- **Buttons**
  - We selected buttons with similar feel to flute buttons
  - Limited options at this size, so not the easiest to press
- **Audio Latency**
  - Reasonable audio latency ~20ms, average Bluetooth latency 100-300ms
  - Prioritized wireless controller over audio latency
- **Length**
  - Arduino Nano and battery mounted at the end of the controller, makes it longer than 26”
  - Easier to fix wires, upload code, change batteries
  - Length at the end of the flute isn’t important because user doesn’t hold there
- **Width**
  - Outer diameter of PVC is ⅜” larger than the flute
  - Prioritized fitting components inside over this small difference

Project Management