Project 4 - CSE 535

HydroFit: Reclaiming Fitness Autonomy

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My part would be to implement a **MATLAB fuzzy controller for fitness meter estimation**.
Github: Link (Added ImpactLab ASU useras collaborator)

Alignment with Guardian Angel:

The integration of the MATLAB fuzzy controller for fitness meter estimation into the Guardian Angel project, **HydroFit**, significantly enhances the app's functionality by offering a sophisticated, personalized assessment of users' fitness levels. This feature supports HydroFit's **dual focus on physical activity and hydration**, providing nuanced fitness tracking essential for motivating users to maintain or improve their health habits. By accurately gauging fitness levels, the system can inform and adjust hydration recommendations, recognizing the interplay between exercise intensity and water needs, thereby ensuring users receive comprehensive health advice tailored to their specific activities and fitness status.

Specification:

Control Flow:

The control flow of the fuzzy controller involves input processing (heart rate, exercise duration, step count) [1] , applying fuzzy logic rules to these inputs, and then producing an output (fitness level). This process is iterative and responsive to the changing input values, reflecting real-time physical activity data.

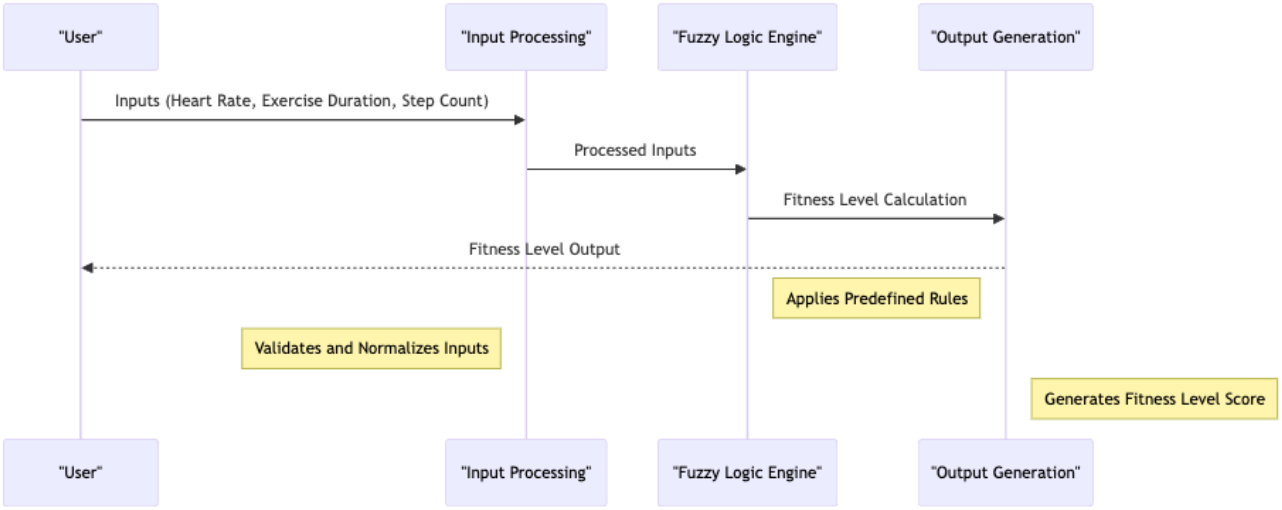

Fig 1. Sequence diagram illustrating the control flow of the MATLAB fuzzy controller

The sequence diagram represents the interaction between different components of the system:

- User: Initiates the process by providing inputs such as heart rate, exercise duration, and step count.
- Input Processing: This component receives the user inputs and prepares them for analysis.
- Fuzzy Logic Engine: Processes the inputs using fuzzy logic rules to estimate the fitness level.
- Output Generation: Generates the fitness level output based on the analysis from the Fuzzy Logic Engine.
- HydroFit App: Receives the fitness level output and displays it to the user. This fitness level information is also used to inform hydration recommendations within the app.

Design:

The architecture involves three primary components: Input Processing, Fuzzy Logic Engine, and Output Generation. Inputs (heart rate, exercise duration, step count) are fed into the Fuzzy Logic Engine, which applies predefined rules to determine the fitness level. The output is then generated as a fitness level score.

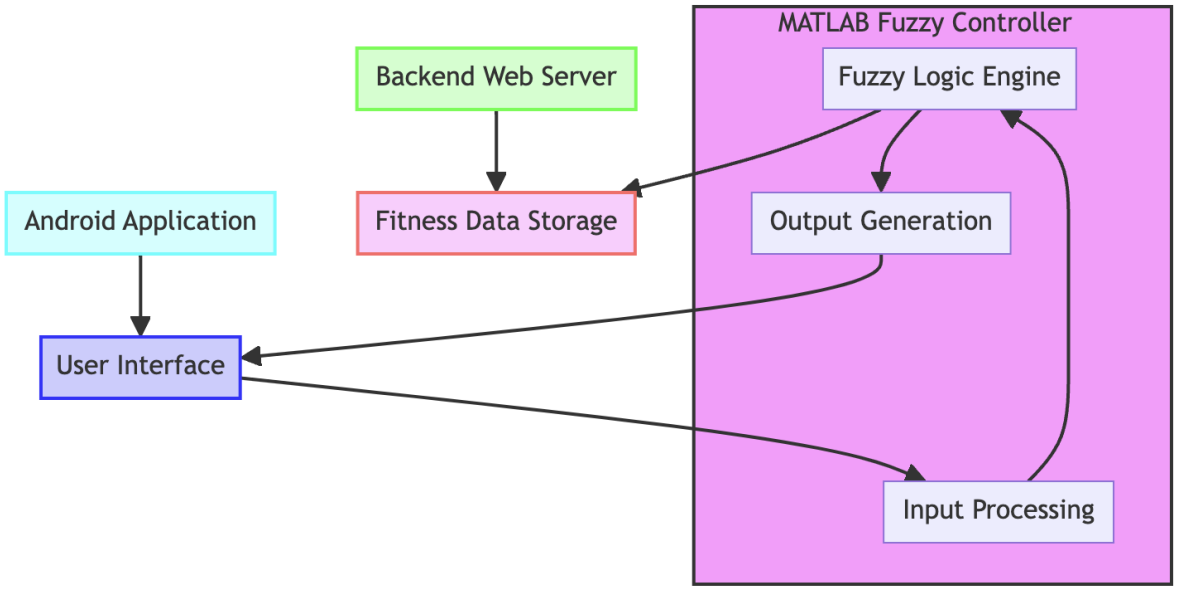

Fig 2. Component architecture diagram

The design is modular, with a clear separation between input processing, rule application, and output generation. This modularity facilitates maintenance and potential future enhancements, such as adding more inputs or rules.

Tech-Stack:

- Core Technology: MATLAB (for developing the fuzzy logic controller).
- Data Analysis Tools: MATLAB Fuzzy Logic Toolbox (for designing fuzzy systems and algorithms).

Testing strategies:

I've chosen **Regression Testing** for my MATLAB Fuzzy Controller component, which is crucial for maintaining the integrity of the system after updates or changes.

- Develop Test Cases: Create test cases for various input scenarios (heart rate, exercise duration, step count) and their expected outputs (fitness levels).
- Automate Tests: Used MATLAB-compatible testing frameworks to automate these test cases, ensuring they run the fuzzy controller and compare actual outputs with expected results.

For example, ran below test-case scenarios to validate the component.

```
Input: Heart Rate = 189, Exercise Duration = 112, Step Count = 10000
Estimated Fitness Level: 87.74 (Excellent)

Input: Heart Rate = 120, Exercise Duration = 60, Step Count = 5000
Estimated Fitness Level: 65.00 (Good)
```

Fig 3. Validated a few test case scenarios using FitnessMeter.

Navigating Challenges:

Challenges Faced:

- **Accuracy of Fuzzy Logic Rules**: Achieving precision in the fuzzy logic rules to accurately represent real-world fitness levels was a significant challenge.
- **Integration with HydroFit App**: Effectively integrating the MATLAB-based fuzzy logic system with the HydroFit mobile application posed technical complexities.

Adaptive Strategies Employed:

- **Refining Fuzzy Logic Rules**: To tackle accuracy issues, we continuously refined the fuzzy logic rules. This involved gathering user feedback and consulting with fitness experts to ensure the rules closely mirrored real fitness scenarios.
- **Seamless Integration Techniques**: For integration challenges, we employed robust APIs and middleware solutions. These tools facilitated a smooth and efficient integration of the MATLAB system with the HydroFit app, ensuring a cohesive user experience.

References:

[1] M. A. Holliday and W. E. Segar, "The maintenance need for water in parenteral fluid therapy," Pediatrics, vol. 19, no. 5, pp. 823–832, 1957. doi:10.1542/peds.19.5.823