Features of Smart Coffee Machine

Group 17 of Real time embedded coding, Glasgow University, 2025

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1.Overview

This system combines biological signal detection (heart rate and blood oxygen levels) with advanced image recognition to assess the user's physical and emotional state. By analyzing these signals, the system assumes the user's mood and emotional state, such as happiness or not. Based on the mood analysis, the recognition module matches the user's emotional state with the ideal coffee cuisine and then automatically brews the selected drink. The goal is to enhance the user's mood or cater to their preferences, providing a personalized coffee experience that aligns with their emotional needs.

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2.Version History

Version	Date	Changes Made	Author
V1.0 stable-release	2025-04-21	Initial release version	Chen Xin Jiaqi Fan Tang Qi Yiyao Wang Junteng Zheng

3.Product Features

3.1 Application scenarios

The coffee machine automatically wakes up and enters the ready state as the user enters the kitchen/living room. When the user's face is in the image recognition area and the finger is placed on the biometric detection module; The screen will show the recognition results of the user's emotional states (happy or unhappy) and biological signs such as heart rate and blood oxygen in real time. After the above two parts of data are obtained stably, the screen and information acquisition should be freeze; The user is prompted for the next action, coffee recipe confirmation or information re-identification. When entering the coffee recipe confirmation phase, the system will recommend different recipes according to users' health status, but the user can still choose the recipe he preferred. After the recipe is confirmed, the coffee making button will be displayed. The user presses the making button, and the coffee starts to be made. While the coffee is being made, casual music is played simultaneously (mute option is provided [with memory function]). When the coffee is ready, an end prompt sound will be played to remind the user that the coffee is finished. When the infrared sensor module is kept low for a certain period of time (no creature is in the visual range), the coffee machine will automatically enter low power mode.

3.2 Basic features

3.2.1 Wake up detection

Under normal conditions, when there is no person in the house where the coffee machine is located. The coffee machine should keep in sleep with low power consumption. As the user enters the room, the coffee machine can sense in real time and wake up automatically. Enter the ready state and prepare for coffee making.

3.2.2 Sleep detection

When the coffee is made and the user left the room for a period of time, the coffee machine should autonomously sense the surrounding environment and actively enter a sleep state to reduce energy consumption.

3.2.3 Emotion recognition & Health states identification

The coffee machine should take real-time images from the camera and extract facial information for analysis. The results of the analysis (happy/unhappy) are used as part of the basic information for recommending coffee in the next phase. The coffee machine should also have the function of obtaining physical health signs, uses the most basic heart rate and blood oxygen as evidence for the next stage to give users whether or not it is suitable to drink a cup of coffee today.

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3.2.4 Coffee recommendation and making

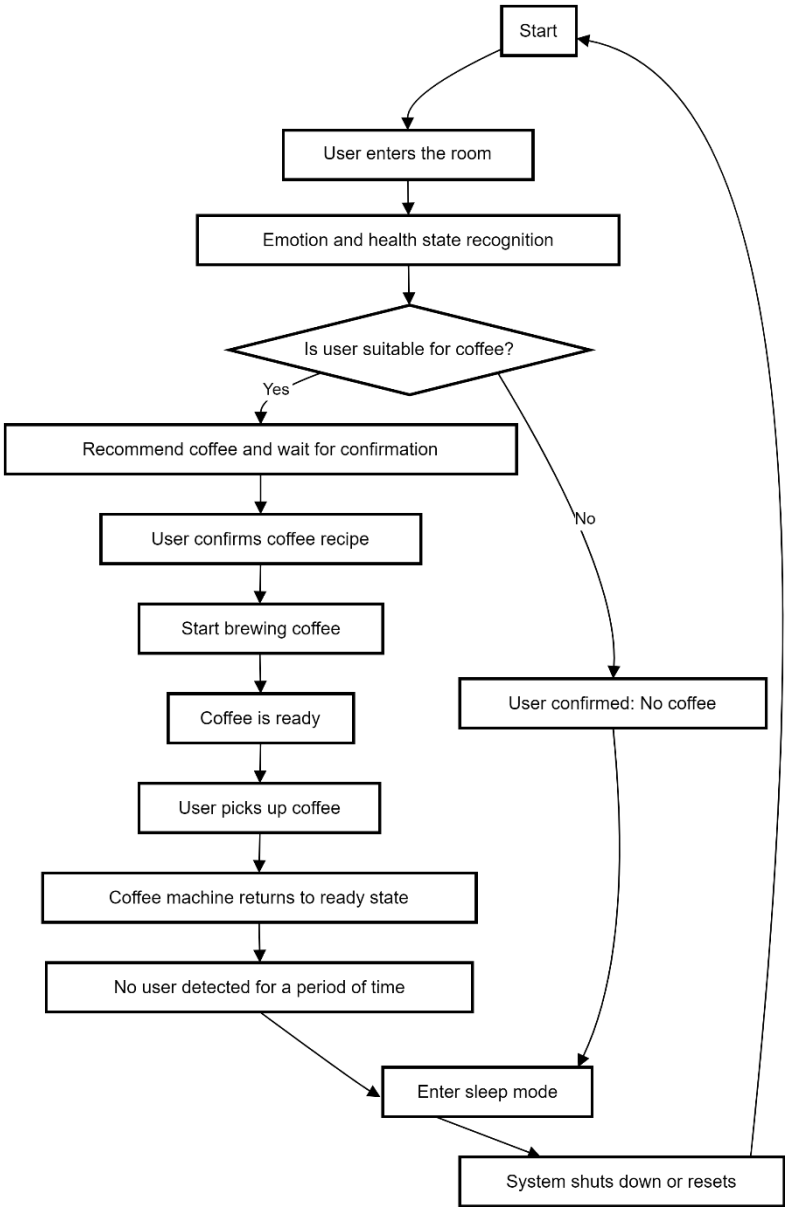
The first step is to suggest whether the user is suitable for coffee today. And users have the final decision. Based on the result of `emotion recognition`, the coffee machine assumes the user's mood state, and according to the analysis, gives a prompt on the screen: "Today your mood is XX, how about a sweeter/bitter cup of XX?" or “Select manually”, which means the drink type and the type of concoction are ultimately manually determined by the user. When the recipe is selected and the making button is pressed, the coffee maker will make the corresponding drink.

3.2.5 Coffee making completed

After the coffee is made, the screen will have an obvious notification to inform the user that the coffee has been made and is waiting to be picked up. The notification should be clear by user manually clicking the on-screen button or the weight sensor detecting that the coffee cup has been removed. After the notification is cleared, the coffee machine will enter the ready state again.

3.3 Coffee machine status flow chart

Flow chart



Status chart

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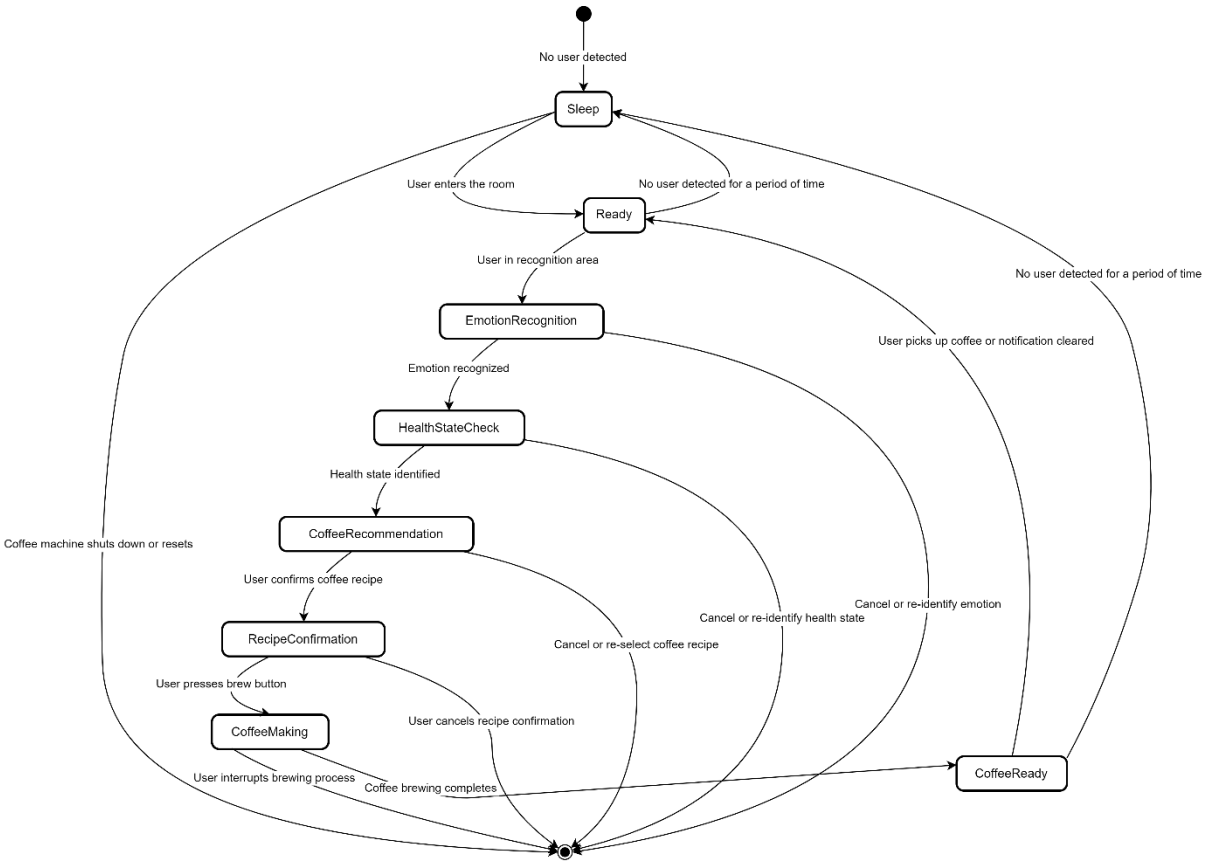

3.4 Critical features

- **Real-time Emotional Analysis**: The system continuously monitors the user's heart rate, blood oxygen levels, and facial expressions to assess their emotional state.
- **Personalized Coffee Recommendations**: Based on the emotional analysis, the system selects the optimal coffee type (e.g., strong coffee for low energy, calming coffee for stress, etc.).
- **Multi-sensory Feedback**: The system may also use additional sensors or environmental data (like temperature or light levels) to further enhance the coffee brewing experience.
- **User Preferences Integration**: Users can customize their coffee preferences (e.g., strength, milk, sugar) for more tailored recommendations, ensuring the system learns and adapts over time.
- **Mobile App/Interface**: Provides users with an interface to view their mood analysis, track their emotional state over time, and manage coffee preferences.
- **Energy and Health Monitoring**: The system tracks biological signals (heart rate,

oxygen levels) and integrates health metrics, providing insights into physical well-being as well as emotional health.

- **Adaptive Learning**: The system improves its emotional analysis and coffee recommendations over time through machine learning, ensuring increasingly accurate and personalized results.

3.5 Other features

- **Privacy and Data Security**: User data, including biological signals and images, should be securely stored and processed. The system must comply with relevant data protection regulations (e.g., GDPR, HIPAA) to ensure privacy.

- **Maintenance and Support**: The system should include automated alerts for when maintenance is needed (e.g., coffee machine descaling, sensor calibration) and provide customer support for troubleshooting.

4.Vision of the future

With the continuous development of technology, the future smart coffee machine will not be limited to simple coffee making. It will also become a core component of the smart home system and integrate into the user's lifestyle.

a. Multibiological Signal Fusion

In the future, the smart coffee machine will not only be able to judge the user's emotional state through facial expression recognition but will also integrate other biological signal sensors, such as blood pressure sensors and body temperature sensors. This will further analyze the user's sleep quality, physical activity, and other factors to provide a more comprehensive assessment of the user's physical condition. This will enhance the smart coffee machine's ability to adjust coffee parameters based on the user's state and adapt to various usage scenarios.

b. Smart Home Integration

In the future, the smart coffee machine plans to work in conjunction with other smart home devices. While brewing coffee, it will automatically adjust the indoor environment through lighting, air purifiers, and other devices to enhance the user's comfort during the waiting period for coffee preparation.

c. Continuous Optimization of Machine Learning Algorithms

With the ongoing iteration of machine learning algorithms, the future smart coffee machine will have stronger learning capabilities. It will not only recommend coffee based on the user's current situation but will also use the accumulated long-term data of the user for deep learning. Over time, the machine will improve its personalized recommendation mechanism, enhancing its position in the furniture configuration.

d. Global Customization Services

With the widespread adoption of technology, the future smart coffee machine is expected to support multilingual and multicultural customization services to meet the needs of users in different countries and regions. The system will be able to adjust the coffee type library (e.g., Italian espresso, Argentine mate tea) based on the user's cultural background and region, improving the adaptability of the product itself.

In summary, the future smart coffee machine will not only be a simple coffee-making tool but will also become a life assistant that deeply integrates the user's physical and psychological conditions, smart home systems, and personal preferences. As artificial intelligence and other technologies continue to develop, it will further realize an intelligent user experience.

Appendix A – Role description

- **User**: The primary person interacting with the system. The user provides biological data (via contact sensor on coffee machine) and visual data (via a camera). The system uses this data to assess their emotional state and automatically brews a coffee that matches their needs.
- **Biological Signal Sensor**: The wearable device or sensor responsible for measuring the user's heart rate and blood oxygen levels. It plays a crucial role in understanding the user's physical state, which is a key input to the emotional analysis.
- **Image Recognition Module**: This component processes the user's facial expressions and emotional cues from their visual input. It uses machine learning and computer vision to detect emotional states and supports the overall mood analysis.
- **Recognition Module**: Analyzes the biological and image data to calculate the emotional state (e.g., happiness, stress). This module determines the best coffee recommendation based on the user's mood, ensuring personalized coffee choices.
- **Brewing System**: A fully automated coffee machine that uses the recognition module's recommendations to brew the appropriate coffee drink based on the user's emotional state and preferences.

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