Study of connected health applications and implementation of a solution forpersonalized and precision medicine

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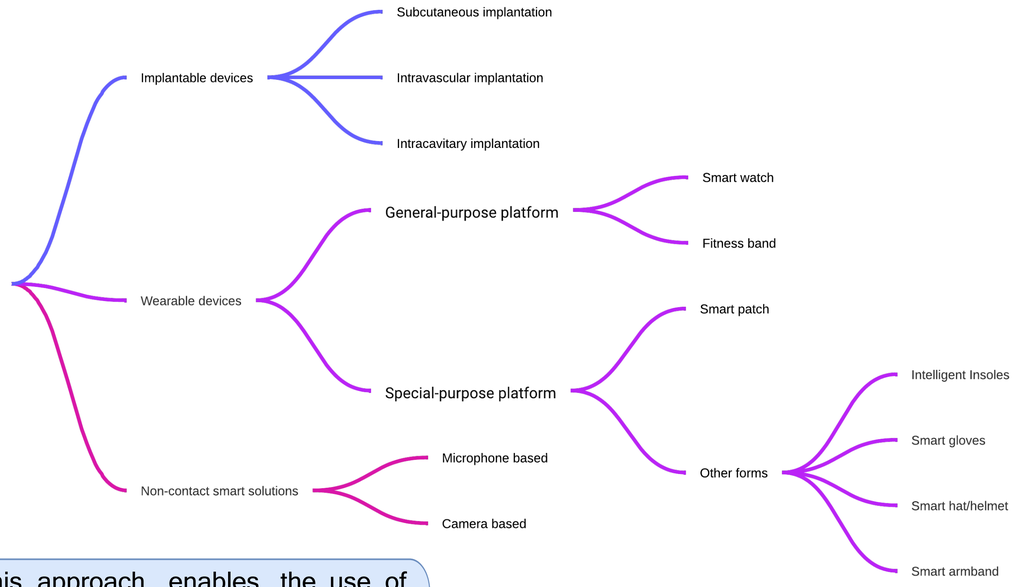
Introduction

This work aims to explore the utilization of connected objects for personalized precision healthcare, and to propose a solution with the objective of employing connected objects to continuously monitor users' health status in daily life, thereby detecting health anomalies and ultimately reducing **delayed diagnosis and misdiagnosis** to facilitate the goals of personalized and precision healthcare.

The first part of this study involves an examination of the current landscape of commercially available products for continuous health monitoring in everyday life, as well as observations on related research.

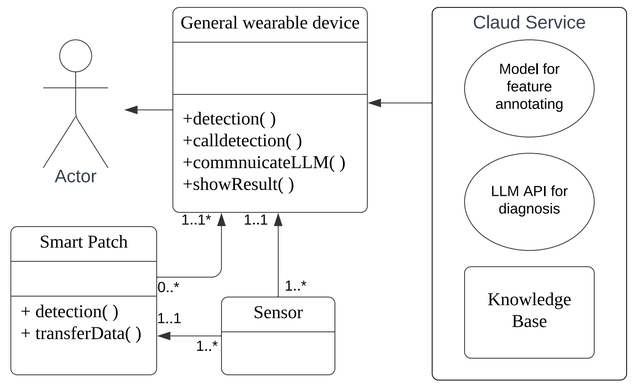
The second part proposes a solution centered around the use of connected objects , with one (or more) serving as a universal platform , supplemented by other specialized connected objects , to monitor health data in daily life . For potential health issues , it employs a timely and instantaneous zero -shot diagnosis using a Large Language Model (LLM) empowered by external knowledge base.

Devices marketed available for daily health monitoring



This approach enables the use of LLMs for medical diagnosis without any fine-tuning and allows for easy adaptation to different subdomains by simply replacing the knowledge base. Its accuracy has been demonstrated to be reliable.

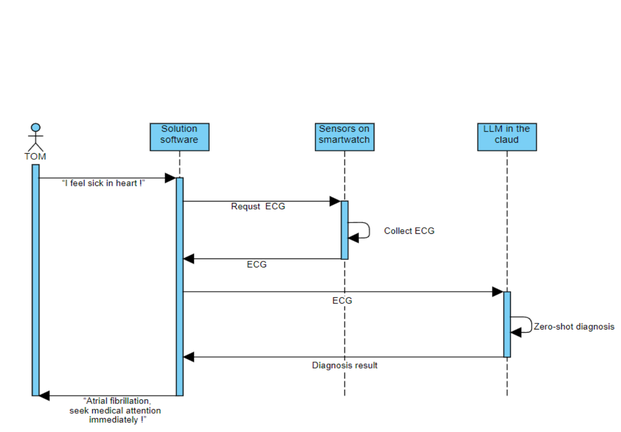
Solution proposed

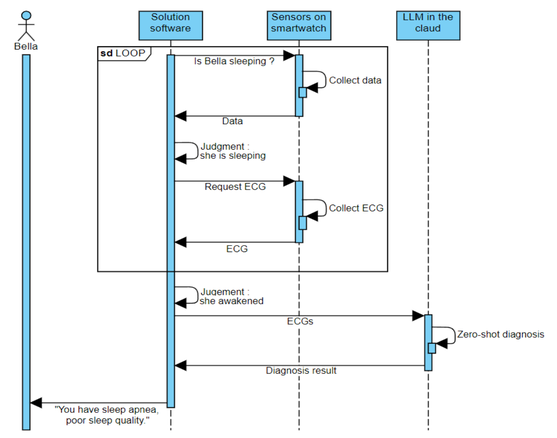


The proposed solution consists of three main components:

1. Wearable device ensemble with health monitoring capabilities: These include a general-purpose smart platforms and some specific-purpose smart patch equipped with sensors and running programs for these sensors.
2. Solution software: installed on general-purpose smart devices, transmit collected data to the cloud and display diagnostic results and recommendations returned from the cloud. It should also include algorithms for automatically initiating health data collection and cloud communication to enable passive monitoring.
3. Services in claud : providing communication interfaces , pre-trained LLM for diagnosis , databases storing relevant professional knowledge, and specific pre-trained model for annotate original health data.

Solution applicated scenario examples





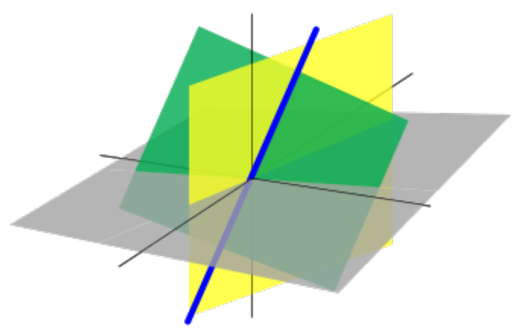
The process of zero-shot diagnosis using LLM empowered by chroma knowledge base

Medical professional knowlegment document

Chunking
The text splitting process

Texts

Embedding
to build a vector space of text



Vector space refer to text

stock

Chroma

ChromaDB is an open-source embedding database that allows for the storage of embedding vector spaces and enables searches within these vector spaces.

reseach

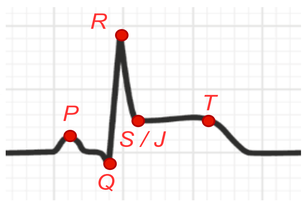
Annotating model

The model that annotates ECG to feature , could be a specialized deep learning model, a specialized algorithm or just a LLM with image recognition capabilities.

How is me ?

Wearable device

Collect



ECG of user

annotating

Features:
- J Amplitude: 12 mv (1.2 mm)
- QRS width: 130 ms
- ...

Mapping

Features will be mapped to vector space based on the embedding method used.

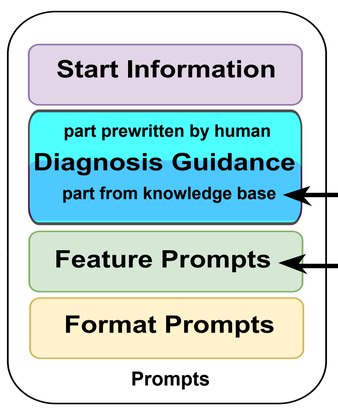
"NORM": {
"Result": false,
"Explanation": "The presence of a notched R wave in lead III indicates a disturrom being considered 'Normal.'"
},
"MI": {
"Result": false,
"Explanation": "Without ST elevation, significant Q waves, or reciprocal changecardial infarction, MI cannot be conclusively determined from the given data."
},
"STTC": {
"Result": true,
"Explanation": "The notching of the R wave in lead III might indicate localizeduggesting ST /T changes. This assessment is in the context of no detailed ST segmented; thus, it broadly falls under this category due to the lack of conclusive data for MI or hypertrophy."
},
....

Show result on wearable device

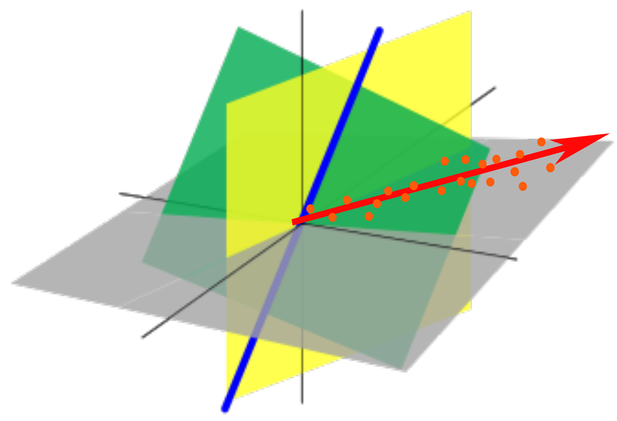
LLM

Given that knowledge is transmitted in the form of prompts, LLM adopted needs to be capable of processing at least 30,000 tokens within a single conversation to be meaningful . This work evaluated the following LLMs which meet this requirement.

Claude 3 GPT-4



Features and their associated knowledge are integrated into complete prompts through a template , which includes pre-written prompts and directive text, as well as instructions for the output format.



closest content selected

we select a specific number of tokens that are closest to the features mapped to the vector space , and these texts will serve as reference knowledge for the LLM during diagnosis, so called associated knowledge.

Conclusion : *This work conducts an analysis on the continuous monitoring of health in daily life using connected health applications to aid in providing personalized and precision medicine . It particularly explores the existing commercial products on the market and reviews existing research . Present circumstances indicate that the use of wearable devices and mobile health data collection methods is gaining popularity and significant attention due to their advantages , such as minimal disruption to patients' normal lives, ease of scalability and customization, deployment and removal convenience, and affordability.*

Simultaneously, this work proposes a detailed design of a scheme that integrates wearable devices-including smartwatches serving as a general platform and smart patches as expandable components, and cloud-based LLM services, utilizing zero-shot diagnosis methods to provide immediate personalized medical diagnostic advice, aiming to reduce diagnostic delay and misdiagnoses to facilitate the implementation of precision medicine. The contribution of proposed solution lies in raising a potential possibility to addressing the issue that impeding precision medicine especially delayed diagnosis caused by the dependence of patients on their own level of awareness and concern regarding their disease and health status on the commencement of traditional medical procedures.