

AI in Medical Healthcare

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Contents

1. Use Cases of AI in Medical Healthcare
2. Some Statistics
3. Use Case 1: AI for Breast Cancer Diagnosis
4. Use Case 2: AI for Sleep Monitoring (using PSG)
5. Use Case 3: AI for non-contact sleep monitoring (using signals)
6. Use Case 4: AI for non-invasive Blood Pressure Monitoring
7. Use Case 5: AI for Health Analysis and Reports Generation
8. Use Case 6: AI for Mental Healthcare
9. Tool and Websites for AI in Healthcare
10. Biomedical Journals Info

1. The purpose to use AI in medical Healthcare

1. Diagnosis (cancer, breast tumor, lungs infection, depression, suicidal risks, cardiosvascular problems, etc.,)
2. Q/A (related to health, medical, physical fitness, etc.,)
3. Analysis
4. Treatment and plan (customized medicine and suggestions)
5. Decision Making (In hospital for making decisions about patients including cancer, diabetes)
6. Report Generation (Discharge summaries, health reports, etc.,)

2. Statistics about breast cancer



Breast Cancer

Breast cancer is the most common cancer in Canadian women, with the exception of non-melanoma skin cancer. While it can also be found in men, male breast cancer is a very rare occurrence. Breast cancer starts in the cells of the mammary gland. Breast tissue covers a larger area than just the breast, extending up to the collarbone and from the armpit to the breastbone.

- In 2022 an estimated 28,600 Canadian women will be diagnosed with breast cancer and 5,500 will die of it.
- Breast cancer accounts for approximately 25% of new cases of cancer and 14% of all cancer deaths in Canadian women.
- **1 in 8 women are expected to develop breast cancer during her lifetime and 1 in 34 will die of it.**
- Almost all breast cancers start in the glandular tissue of the breast and are known as adenocarcinomas. Cancer cells may start within the ducts (ductal carcinoma) or lobules (lobular carcinoma). Ductal carcinoma is the most common type of breast cancer, accounting for approximately 90% of all in situ breast carcinomas and 70% of all invasive breast carcinomas.

Reference: <https://www.canada.ca/en/public-health/services/chronic-diseases/cancer/breast-cancer.html>

2. Statistics (Cont...)



How common is breast cancer?

Breast cancer is the most common cancer in women in the United States, except for skin cancers. It accounts for about 30% (or 1 in 3) of all new female cancers each year.

The American Cancer Society's estimates for breast cancer in the United States for 2024 are:

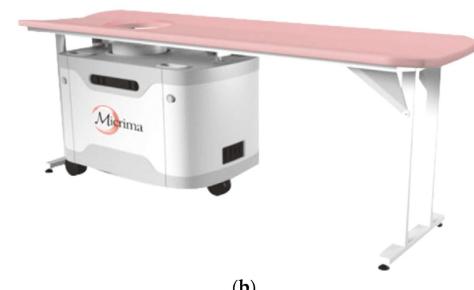
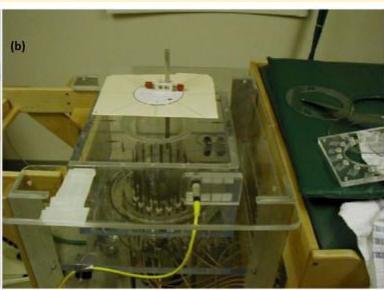
- About 310,720 new cases of invasive breast cancer will be diagnosed in women.
- About 56,500 new cases of ductal carcinoma in situ (DCIS) will be diagnosed.
- About 42,250 women will die from breast cancer.

Breast cancer mainly occurs in middle-aged and older women. The median age at the time of breast cancer diagnosis is 62. This means half of the women who developed breast cancer are 62 years of age or younger when they are diagnosed. A very small number of women diagnosed with breast cancer are younger than 45.

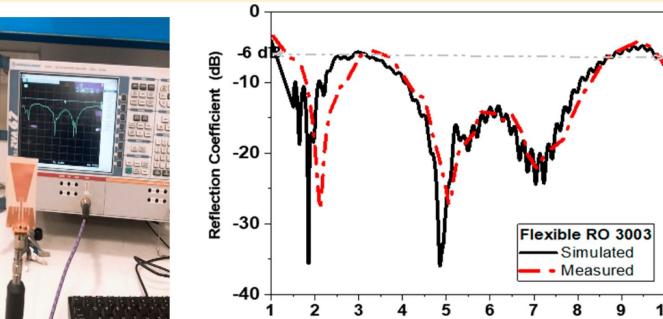
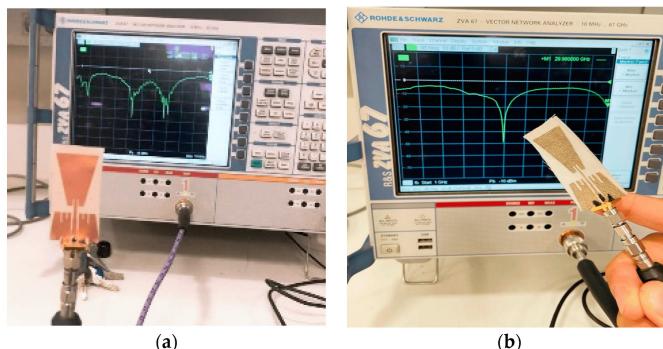
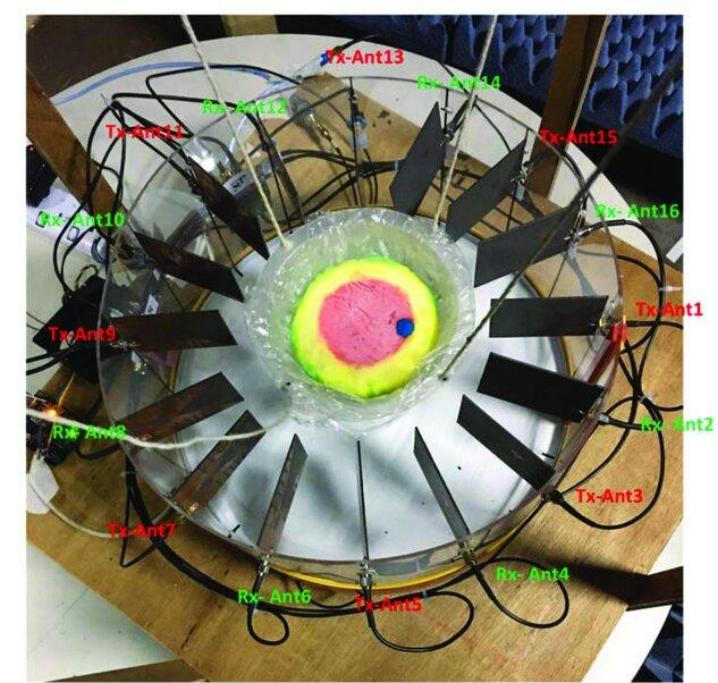
Reference: <https://www.cancer.org/>

Use Case 1: AI for Breast Cancer Detection using microwave sensing

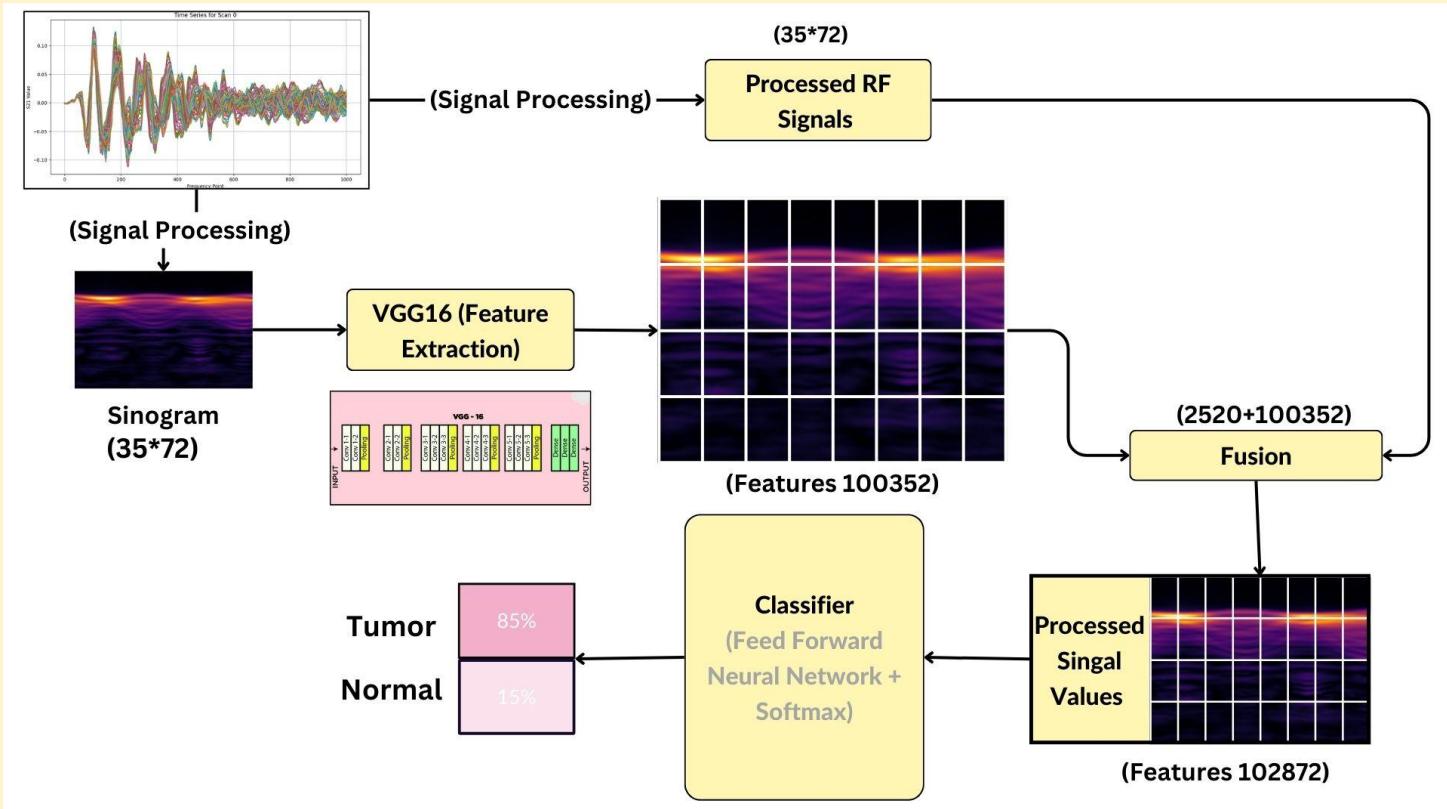
- Breast microwave imaging uses microwaves to create images of the breast tissues
- Uses non-ionizing radiations (Ionizing radiations are used in MRI, X-ray, Ultrasound)
- Safer for patients compared with mammography
- Cancerous and non-cancerous tissues have different electrical properties, microwaves are scattered differently



Use Case 1: Breast Cancer Detection (Diagnosis)



Use Case 1: Breast Cancer Detection



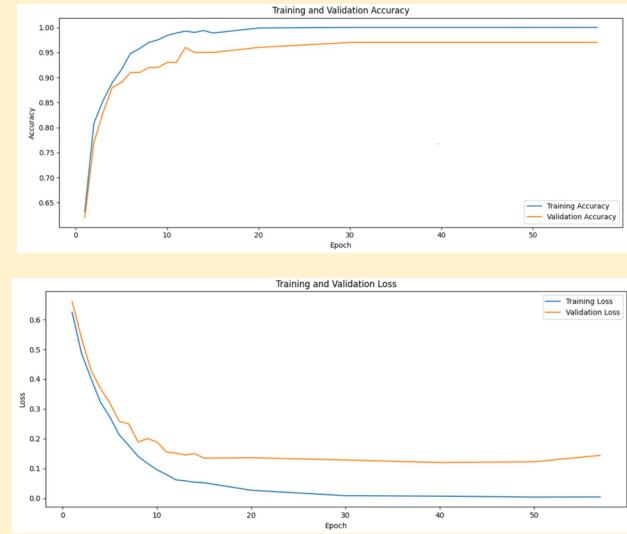
Results

Table 1: Performance Comparison of Various Methods

Method 1: DSA					
Performance Metrics	LR	DT	RF	SVM	XGBoost
Accuracy	0.940	0.820	0.860	0.840	0.860
Recall	1.000	0.880	0.877	0.960	0.960
Specificity	0.880	0.840	0.720	0.720	0.760
AUR ROC	0.971	0.860	0.954	0.930	0.960
Method 2: SBME					
Performance Metrics	LR	DT	RF	SVM	XGBoost
Accuracy	0.68	0.48	0.46	0.58	0.5
Recall	0.64	0.56	0.4	0.44	0.4
Specificity	0.66	0.6	0.52	0.72	0.56
AUR ROC	0.72	0.5	0.45	0.58	0.5
Method 3: MSP					
Performance Metrics	LR	DT	RF	SVM	XGBoost
Accuracy	0.86	0.8	0.88	0.78	0.86
Recall	0.96	0.8	0.96	0.56	0.92
Specificity	0.76	0.8	0.8	1	0.8
AUR ROC	0.86	0.8	0.88	0.78	0.86
Method 4: MDFBME - Pretrained					
Performance Metrics	VGG16 + CNN	ResNet50 + CNN	ViT.b.16 + CNN		
Accuracy	0.98	0.94	0.94		
Recall	1	1	0.89		
Specificity	0.96	0.88	1		
AUR ROC	0.9744	0.9568	0.95		
Method 5: MDFBME - Non-pretrained					
Performance Metrics	VGG16 + CNN	ResNet + CNN	ViT.b.16 + CNN		
Accuracy	0.84	0.9	0.82		
Recall	0.72	0.96	0.88		
Specificity	0.9	0.84	0.76		
AUR ROC	0.9568	0.932	0.93		

Definitions of Terms

- **DSA (Direct Signal Analysis) SBME:** Direct analysis of signals without transformation into spectrograms.
- **SBME (Spectrogram-Based Model Evaluation) Signal Only:** Evaluation based on spectrograms derived from signal data only.
- **MSP (Multimodal Signal Processing) Signal + Spectrogram:** Processing signals and their corresponding spectrograms simultaneously.
- **MDFBME (Multimodal Deep Feature-Based Model Evaluation):** Evaluation using deep features extracted from multimodal data, including signals and spectrograms.



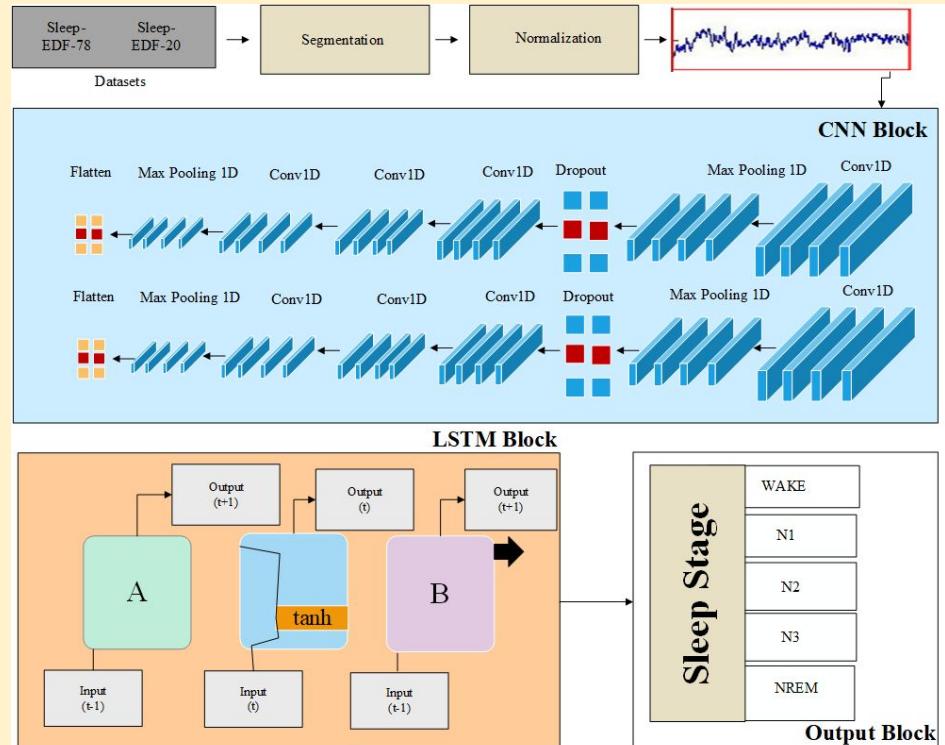
Use cases 2 - Sleep Monitoring using EEG

1. Sleep impacts memory, mood, health, and growth, monitoring sleep is very important, as long time bad quality sleep can cause depression, anxiety, and other problems
2. Physiological signals acquired from EEG, radars, can help monitor the sleep
3. The Polysomnography (PSG) monitors many body functions, including brain activity (EEG), eye movements (EOG), muscle activity or skeletal muscle activation (EMG), and heart rhythm (ECG)

Use Case 2: Hybrid Sleeper Model for Sleep Stage Monitoring using Single Channel EEG (Electroencephalogram)

BACKGROUND: By using PSG data, considered the gold standard, this study highlights the importance and cost-effectiveness of classifying sleep stages from a single EEG channel, addressing a critical gap in understanding sleep patterns for timely health management.

METHOD: We propose a hybrid (CNN + LSTM) architecture called "Sleeper" for classifying sleep stages using a single EEG channel. The architecture employs fixed-size parallel-stacked convolutional filters to extract both fine and coarse features, capturing low-frequency and high-frequency elements. An LSTM block is integrated to capture the temporal representation of the data, facilitating efficient classification.



Use Case 3: AI for Non-Contact Sleep Monitoring

1. Sleep restores body and brain functions, conserves energy, secretes hormones, and stores memories.
2. Sleep Deprivation Leads to poor immunity, higher risk of chronic diseases, weight gain, increased depression, decreased libido, impaired emotional control, and worse memory performance.
3. Sleep monitoring is crucial for diagnosing health conditions and ensuring overall well-being.
4. PSG monitors sleep stages and quality by recording brain waves, blood oxygen levels, breathing, heart rates, and movements.
5. Uncomfortable due to the need for at least 22 electrodes.
6. Unsuitable for long-term monitoring.
7. Specialized labs and trained technologists are required.
8. Contactless sleep-stage detection with radar sensors offers a more natural monitoring environment, overcoming PSG's limitations.

Use Case 3: Background and Significance of Research

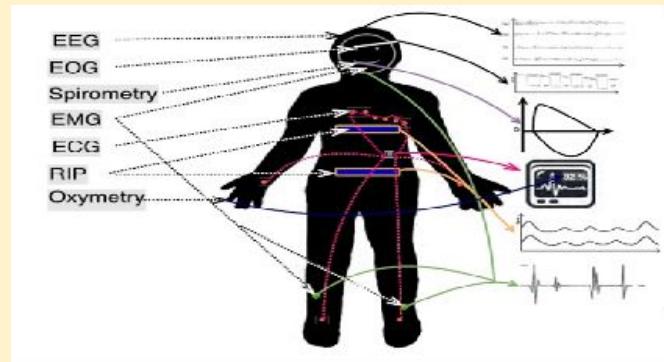
- Sleep, a fundamental human need, plays a critical role in our physical health, emotional well-being, and cognitive functioning.

Limitations of Contact-Based Monitoring Methods

- Polysomnography (PSG), an intricate process involving the measurement of various physiological parameters (EEG, ECG, EOG, EMG, SpO₂).
- Requires attachment of multiple sensors to the body.

Rise of Non-Contact Monitoring Techniques

- Less intrusive and more user-friendly
- Eliminate the need for direct physical contact
- The integration of Radio Frequency technologies
- Radar Sensors, Wi-Fi etc



Use Case 3: NightWaves Net: Multiple RF Technologies for Noncontact Sleep Monitoring

Four Different RF Technologies

- UWB-CIR RF Signals (3.77-4.24 GHz)
- Wi-Fi CSI RF Signals (5 GHz)
- Zigbee RSS RF Signals (2.4 GHz)
- sub-1 dB quantized RSS (400-1000 MHz)

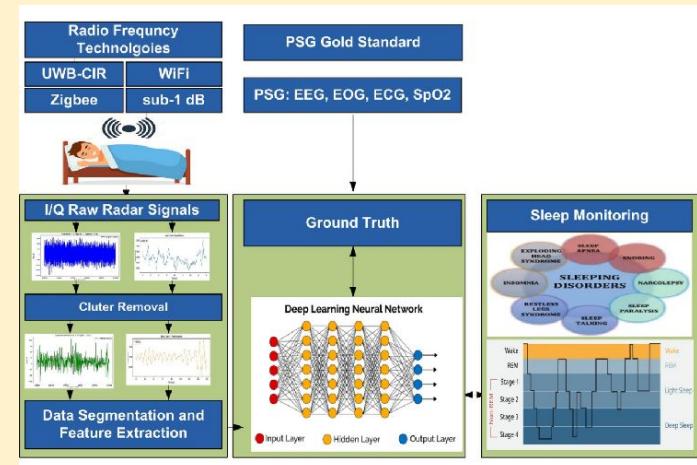
PSG Aligned Sleep States Labels

Machine Learning

- Supervised: Decision Tree, Support Vector Machine, K-Nearest Neighbors,
- Ensemble: Random Forest, Gradient Boosting and Boosted Trees, Bagging and Bagged Trees, XGBoost, AdaBoost

Deep Learning

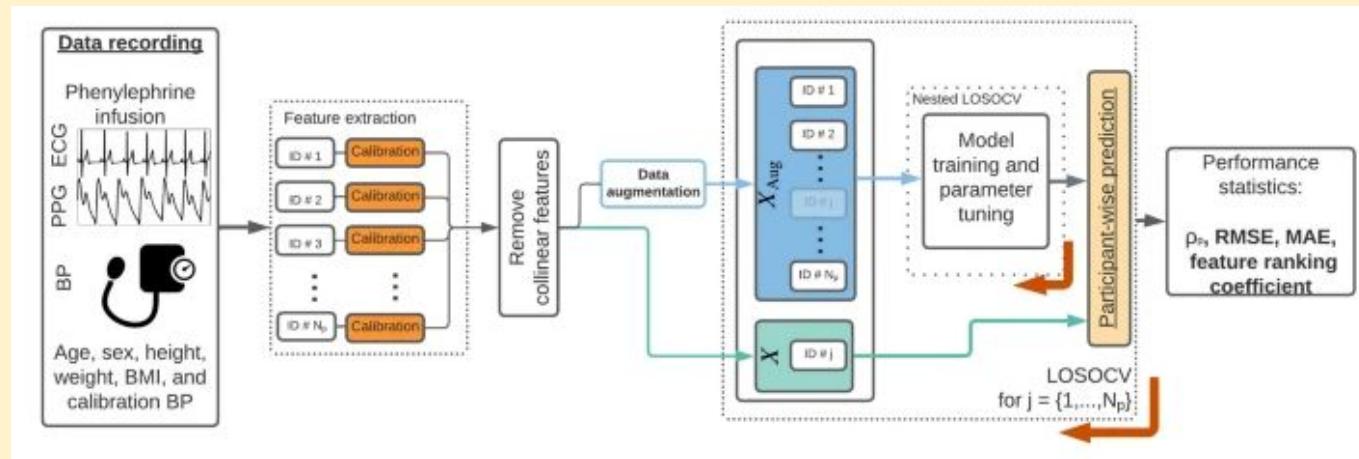
- Hybrid CNN-LSTM
- BiLSTM
- Attention LSTM
- Transformers
- Mamba, SSM (State Space Model)
- xLSTM



Use Case 3: Non-invasive Blood Pressure Monitoring

BACKGROUND: Predicting blood pressure (BP) from electrocardiography (ECG) and photoplethysmography (PPG) is essential for noninvasive, continuous monitoring and management.

METHOD: The proposed CNN-BiLSTM model utilizes convolutional layers to extract features from ECG and PPG signals, followed by bidirectional and unidirectional LSTMs to capture temporal dependencies. This architecture, combined with fully connected layers, aims to predict systolic and diastolic blood pressure with improved accuracy by leveraging both morphological and temporal features.



LLMs in Medical Healthcare

1. Visual Questioning Answering
2. Information Retrieval
3. Dialogue
4. Text Classification
5. Report Generation
6. Image Segmentation
7. Question Answering

Artificial Intelligence Generated Content

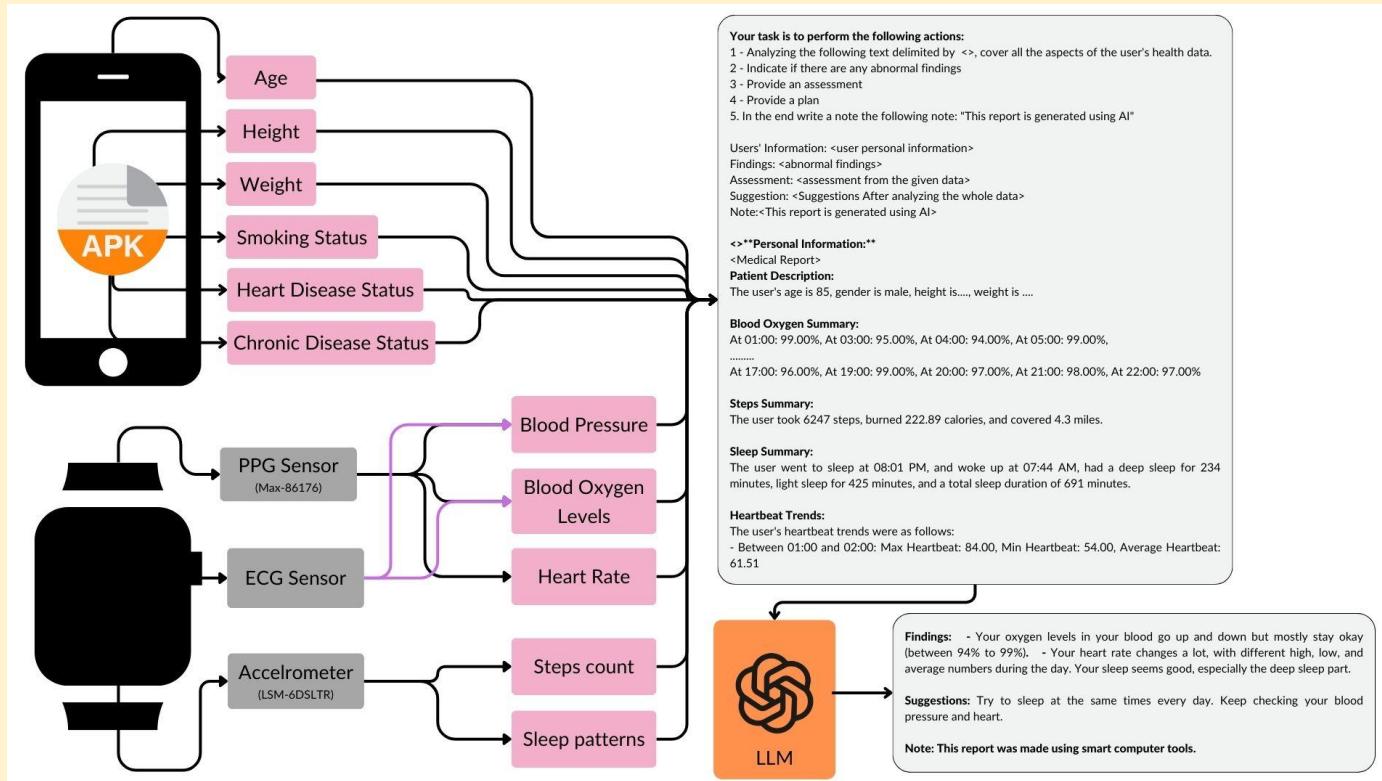


Hugging Face Models

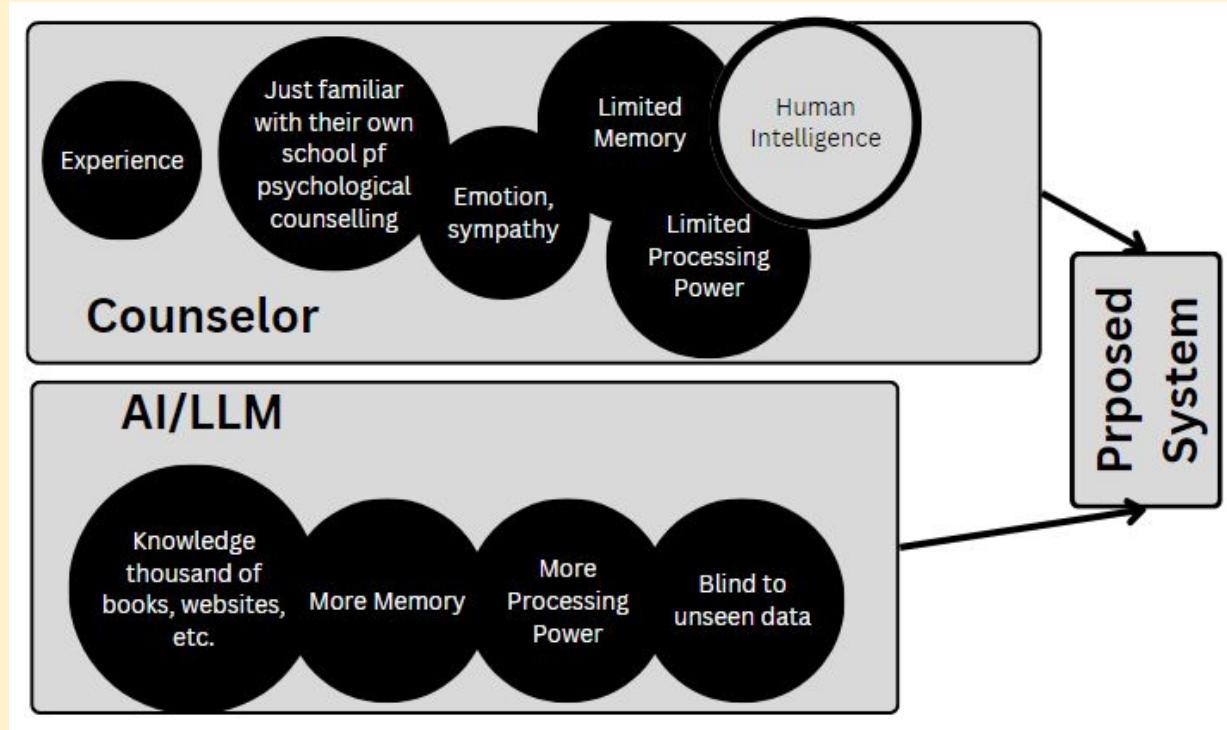
The image shows the Hugging Face Model Hub interface, which categorizes pre-trained models into several groups:

- Multimodal**: Includes Image-Text-to-Text, Visual Question Answering, and Document Question Answering.
- Computer Vision**: Includes Depth Estimation, Image Classification, Object Detection, Image Segmentation, Text-to-Image, Image-to-Text, Image-to-Image, Image-to-Video, Unconditional Image Generation, Video Classification, Text-to-Video, Zero-Shot Image Classification, Mask Generation, Zero-Shot Object Detection, Text-to-3D, Image-to-3D, and Image Feature Extraction.
- Natural Language Processing**: Includes Text Classification, Token Classification, Table Question Answering, Question Answering, Zero-Shot Classification, Translation, Summarization, Feature Extraction, Text Generation, Text2Text Generation, Fill-Mask, Sentence Similarity, Text-to-Speech, Text-to-Audio, Automatic Speech Recognition, Audio-to-Audio, Audio Classification, and Voice Activity Detection.
- Tabular**: Includes Tabular Classification, Tabular Regression, and Time Series Forecasting.
- Reinforcement Learning**: Includes Reinforcement Learning and Robotics.
- Other**: Includes Graph Machine Learning.

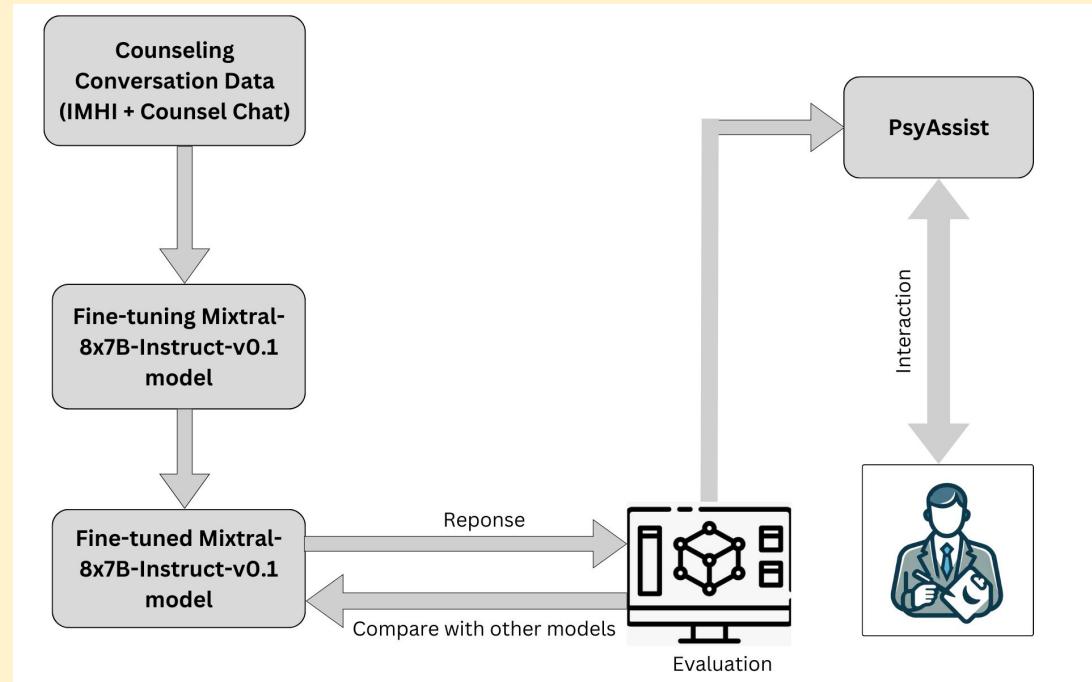
Use Case 4: LLMs for Health Analysis & Report Generation



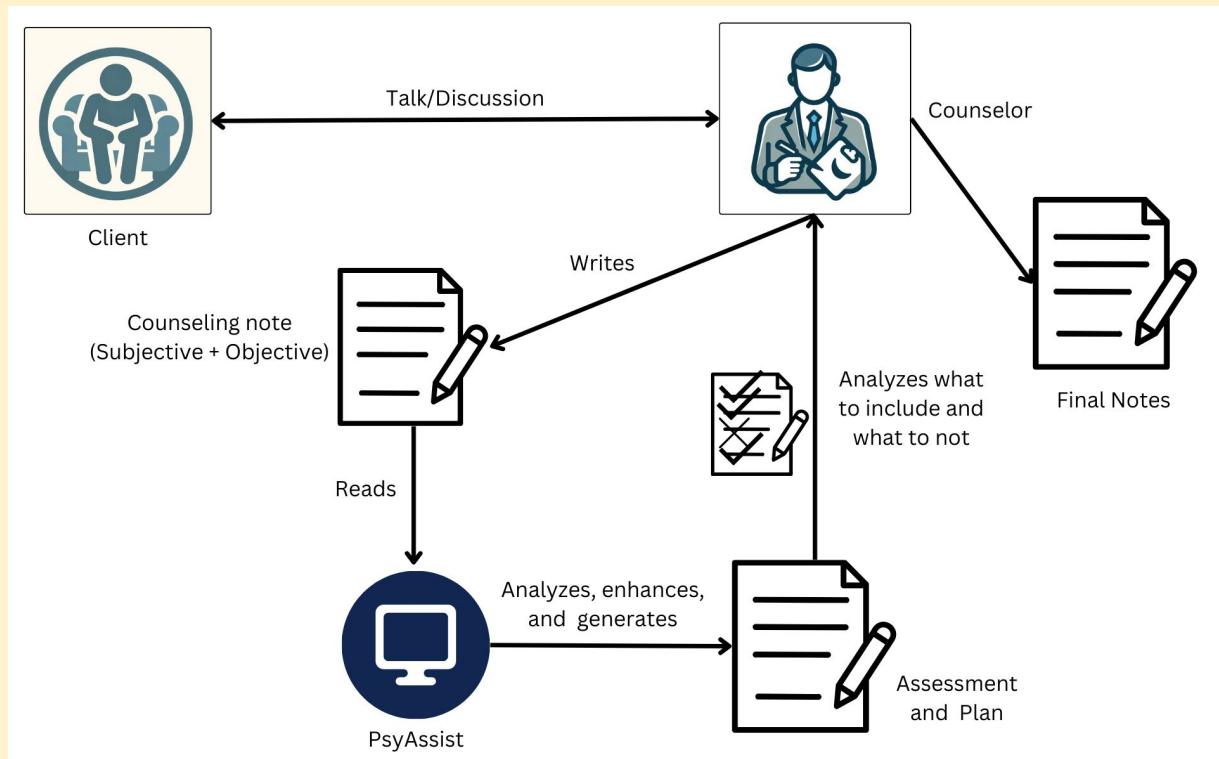
Use Case 5: PsyAssist: Advancing Mental Healthcare



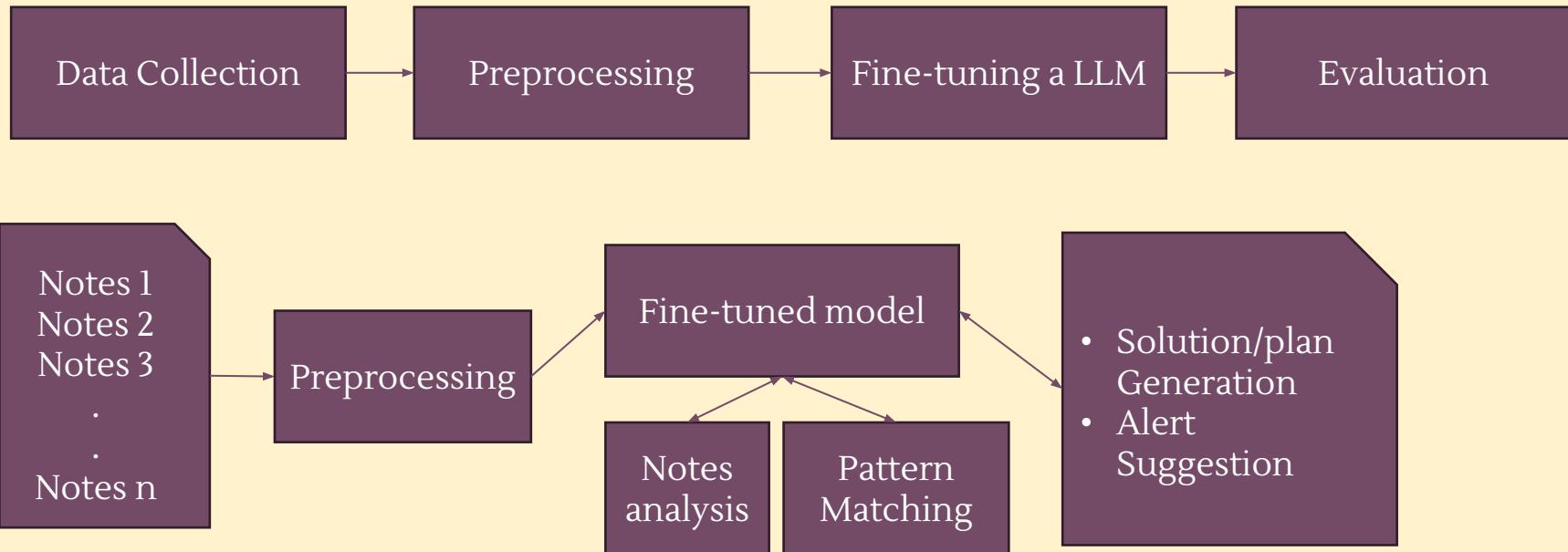
Use Case 5: PsyAssist

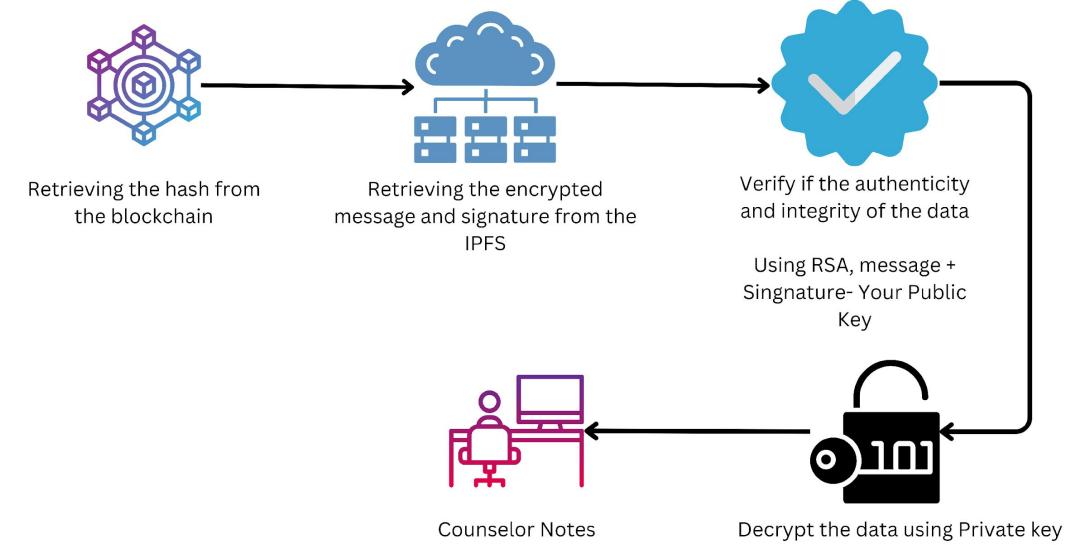


Use Case 5: PsyAssist



PROPOSED METHODOLOGY – LLM SIDE





Model	Param.	DR	Dreaddit	IRF	MultiWD	SAD
LLaMA-7B	7B	58.91	53.51	38.02	40.1	11.04
LLaMA-13B	13B	54.07	36.28	38.89	53.65	13.2
ChatGPT	175B	82.41	71.79	41.33	62.72	54.05
GPT-4	175B	82.0	78.18	51.75	62.58	55.68
Gemini Pro	Unknown	74.81	45.17	57.23	73.33	61.92
PsyAssist	46.7B	76.88	77.37	71.23	66.61	55.58

Comparison of Answers by ChatGPT 3.5 and PsyAssist - Depression Test(DR) Dataset

Question:

Consider this post: "Ancestry.com - is it safe? Hello! :) I'm a new user so if this post ends up in a weird place/thread, pls bear w me. Has anyone used Ancestry.com lately? They offer a two week trial but still require your credit card information. Is this suspicious? It doesn't cost anything for the first two weeks, and then you can end the trial so you don't have to pay anything even then, but I just feel a little uncomfortable dialing my credit card information on there online.... Am I being too doub... Question: Does the poster suffer from depression?

Answer by GPT 3.5: No, the poster does not suffer from depression. The post does not exhibit strong emotional indicators of depression. It primarily focuses on a specific concern regarding the safety of using Ancestry.com and asking for advice and experiences from other users. While there is a slight hint of uncertainty or doubt, it does not prominently display the profound hopelessness, despair, or self-esteem issues commonly associated with depression. The tone of the post seems more pragmatic and seeking information rather than expressing overwhel...

Answer by PsyAssist: There is no evidence in the text provided to suggest that the poster suffers from depression. The poster expresses concern about sharing their credit card information online, which is a common worry among many internet users, and asks for reassurance and advice based on others' experiences with Ancestry.com. This behavior does not necessarily indicate mental health issues.

Comparison of Answers by ChatGPT 4.0 and PsyAssist - Open Q/A

Question:

Some time ago, I wanted to jump off the balcony of school. I never thought of dying before. The main reason is that the people who like me hate me. I deny that I miss it day and night, and I can't see it. Usually, the pressure is very high, and the relationship between the family It's also a mess. Although there is a father who loves me, the rooftop is cold in autumn, but I didn't jump off when I was most uncomfortable, so since I survived, I will live well.

Answer by GPT 3.5: I'm truly sorry to hear about the difficulties and distress you've experienced. It's courageous of you to share such a personal experience, and I'm relieved to know that you chose to stay safe. Remember, it's important to seek support during tough times. Talking to someone you trust, whether it's a friend, family member, or a professional, can provide comfort and guidance. Your life is valuable, and there are people who care and can help you through these challenging times. If you're ever feeling overwhelmed, please don't hesitate to reach out for support from mental health professionals or hotlines. You're not alone in this, and there's strength in seeking help.

Answer by PsyAssist: I'm sorry to hear that you have felt this way in the past. It sounds like you were experiencing some intense emotions and struggles with relationships at school and within your family. Remember that it's okay to feel overwhelmed and to seek help when needed. There are resources available for you such as trusted adults (like parents, teachers, or counselors) who care about your well-being and want to support you. Additionally, if feelings of sadness persist, don't hesitate to reach out to mental health professionals. They have the expertise to provide strategies and tools to cope during difficult times. Just remember that things will get better and there are always options for seeking help.

Benefits of PsyAssist

Early Intervention: The system can help counselors identify clients at risk of mental health issues early, allowing for timely intervention.

Enhanced Client Understanding: By analyzing patterns in counseling notes, counselors can gain deeper insights into their clients' emotional well-being.

Improved Decision-Making: The system assists counselors in making more informed decisions and tailoring their approach to individual clients.

Continual Learning: The system can continually improve its analysis by learning from new data, making it more effective over time.

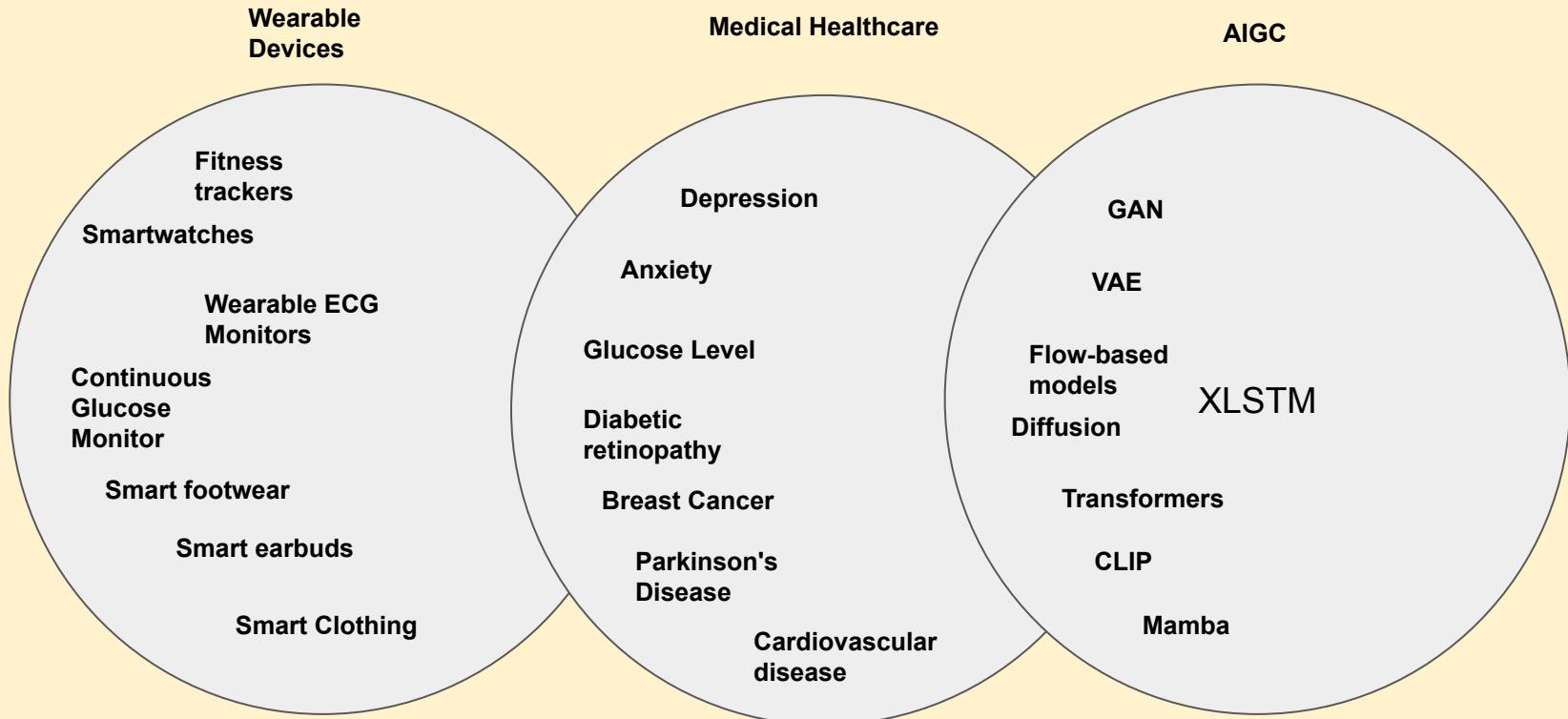
Ethical Considerations : Emphasize the ethical use of the system, clarifying that it is a tool to aid counselors, not a replacement for human expertise.

Wearable Devices and AIGC

AIGC refers to content that is generated using advanced Generative AI (GAI) techniques, as opposed to being created by human authors, which can automate the creation of large amount of content in a short amount of time. [1]

1. Cao, Y., Li, S., Liu, Y., Yan, Z., Dai, Y., Yu, P.S. and Sun, L., 2023. A comprehensive survey of ai-generated content (aigc): A history of generative ai from gan to chatgpt. *arXiv preprint arXiv:2303.04226*.

Introduction



1. Wu, J., Gan, W., Chen, Z., Wan, S. and Lin, H., 2023. Ai-generated content (aigc): A survey. arXiv preprint arXiv:2304.06632.

Literature review

1. There is a lack of reliable technical **BioSignal to Text engineers** to be able to increase the **reliability** of use of models in medical and clinical domain where preparation of reports per test or procedure is a routine task. [1]
2. Medical Knowledge Self-Assessment Program (MKSAP), a self-assessment tool for physicians developed by the American College of Physicians. Previously, GPT-3.5 managed to score ~53%. **GPT-4 scored ~75%**, according to OpenAI. [2]
3. Many studies focused on the use of Generative AI models in NLP or medical images, but the applications of the models remain **unattended in the domain of biomedical signals**, despite the fact that similar tasks of report generation and drafting are involved.

1. Y. Shen, K. Song, X. Tan, D. Li, W. Lu, and Y. Zhuang, "HuggingGPT: Solving AI tasks with ChatGPT and its friends in Huggingface," arXiv preprint arXiv:2303.17580, 2023.
2. GPT-4 is here. how can doctors use generative AI now? — Chatbots can be helpful as "first-draft" office or research assistants, Mar. 2023. [Online]. Available: <https://www.medpagetoday.com/special-reports/exclusives/103616>.
3. BioSignal Copilot: Leveraging the power of LLMs in drafting reports for biomedical signals Chunyu Liu, Yongpei Ma, Kavitha Kothur, Armin Nikpour, Omid Kavehei medRxiv 2023.06.28.23291916; doi: <https://doi.org/10.1101/2023.06.28.23291916>

Sensors in smart watches

1. Accelerometer - acceleration, movement, step counter
2. PPG (photoplethysmography) - monitor heart rate
3. ECG - measures electrical activity of the heart
4. Skin Temperature Sensor - measures' skin temperature
5. GPS - Location tracking

Digital Biomarkers



Sleep Detection



Temperature



Pulse rate



Wearing
detection



Pulse rate
variability



Activity
Classification



Respiratory rate



Steps



Electrodermal
activity (EDA):
Skin
Conductance
Level (SCL)



Activity Counts

How wearable devices can promote healthcare with AIGC?

1. Continuous Monitoring & Early Detection
2. Personalized Healthcare insights
3. Remote health monitoring
4. Report Generation from Biomedical Signals

AIGC and Wearable

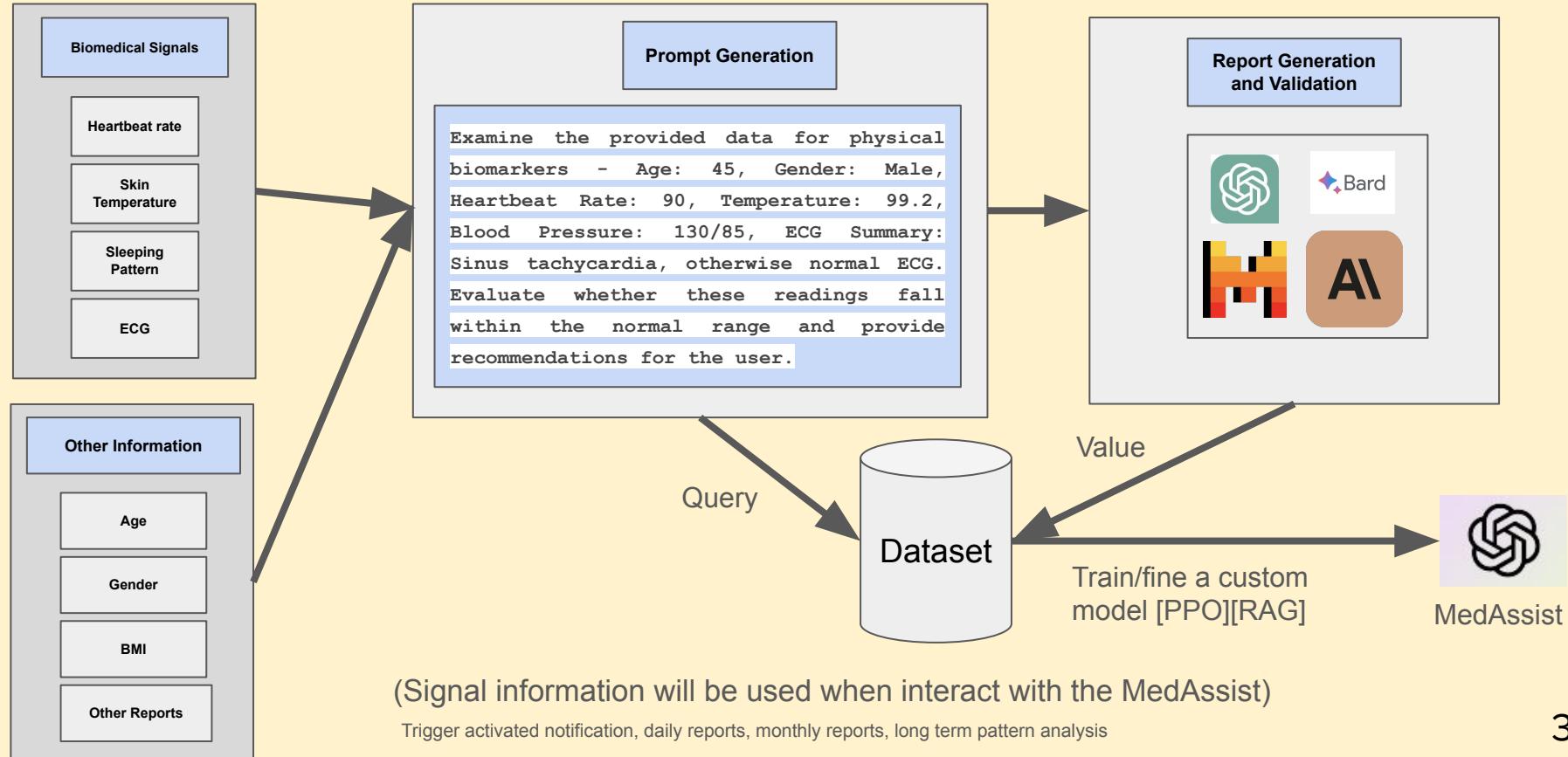
Examine the provided physical biomarkers data for an identity-
Age is 45, Gender is Male, Heartbeat Rate is 90, Skin Temperature
is 99.2F, Blood Pressure is 130/85, and ECG Summary is Sinus
tachycardia, otherwise normal ECG. Evaluate whether these
readings fall within the normal range and provide
recommendations for the user. Please create only a 5-line
summary, Please write it into a suggestive manner.

3/5/2024, 4:01:08 PM

At 45 years old, your resting heartbeat rate of 90 is within the normal range, but it's advisable to monitor for consistency. A skin temperature of 99.2°F may suggest a mild fever; observe for any changes or accompanying symptoms. Your blood pressure reading is on the higher side, indicating a need for lifestyle adjustments to lower the risk of hypertension. The presence of sinus tachycardia on an otherwise normal ECG warrants a discussion with your healthcare provider to explore potential causes. Overall, maintaining a healthy lifestyle and seeking medical advice for the tachycardia and blood pressure management is recommended.

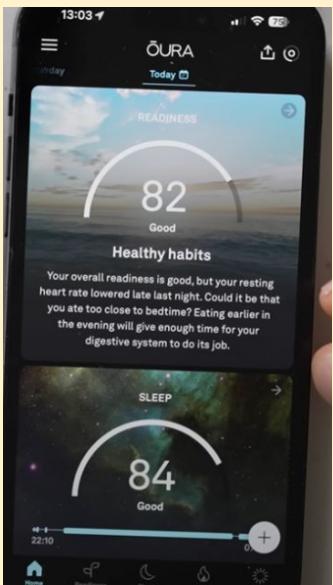
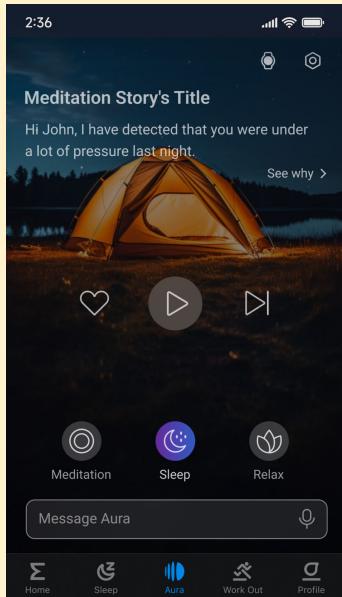
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AIGC and Wearable



Existing Applications using AIGC

Zepp Coach by Amazfit - Aura Band - trained to act as a fitness coach



- AI Chat Service
- AI- Generated Sleep aid: Create customized stories based on the real time heartbeat rate
- AI sleep melodies
- Fitness coach

<https://aura.zepp.com/>

Multimodal LLMs for Diabetes Management

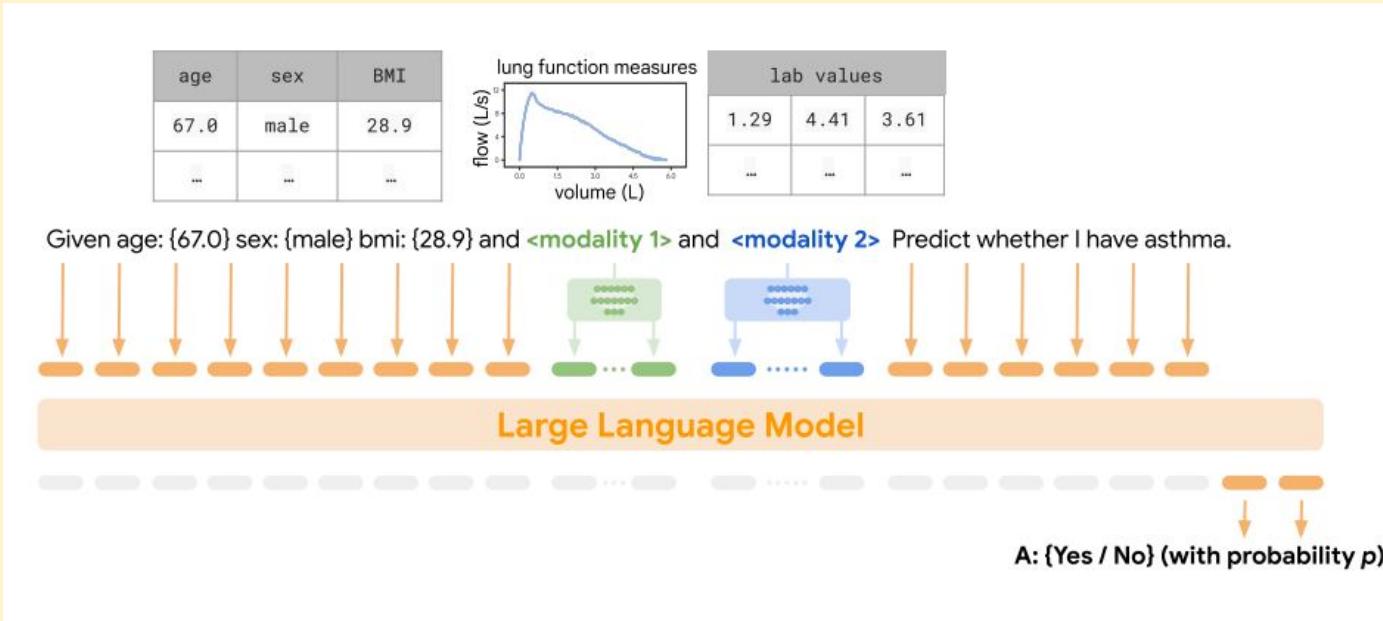


Image reference: Belyaeva, A., Cosentino, J., Hormozdiari, F., Eswaran, K., Shetty, S., Corrado, G., Carroll, A., McLean, C.Y. and Furlotte, N.A., 2023, July. Multimodal LLMs for health grounded in individual-specific data. In *Workshop on Machine Learning for Multimodal Healthcare Data* (pp. 86-102). Cham: Springer Nature Switzerland.

How it will work?

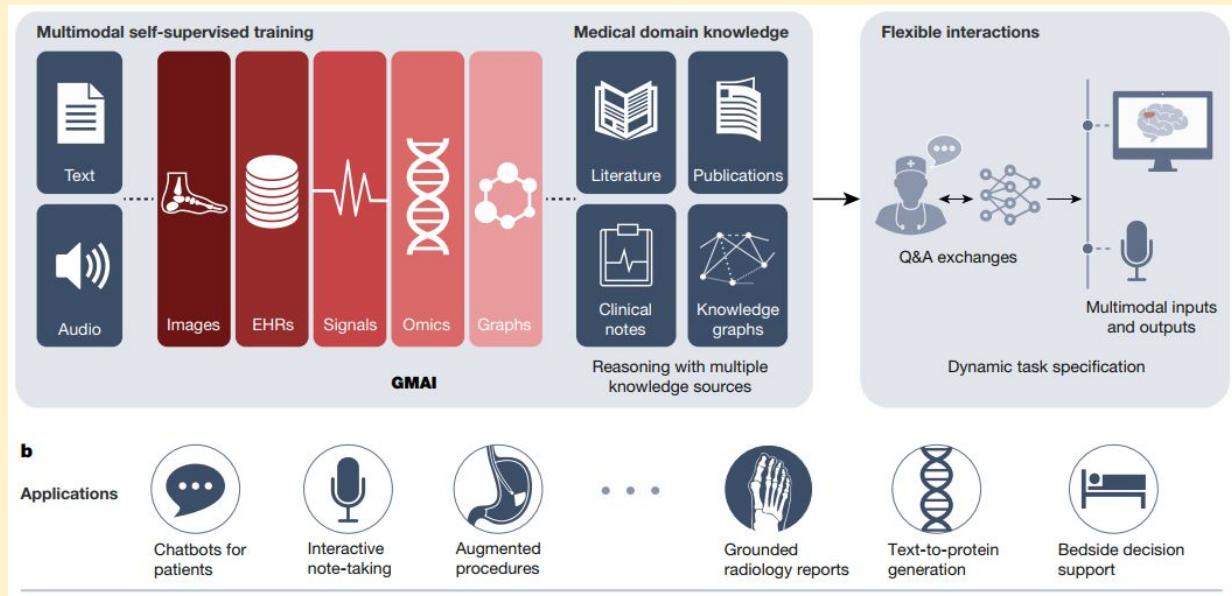


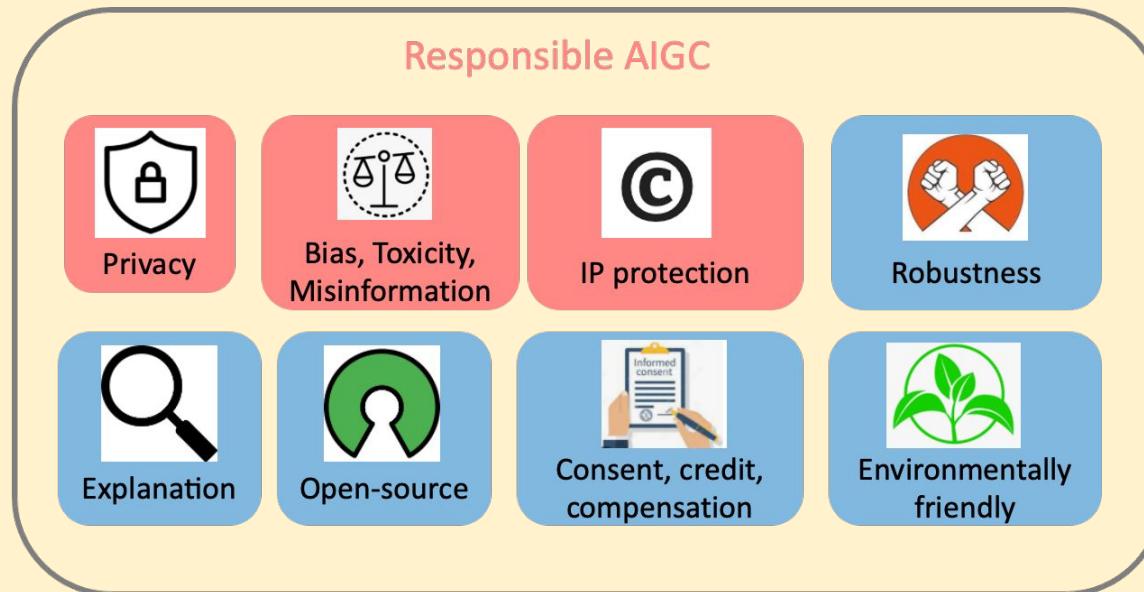
Image reference: Moor, M., Banerjee, O., Abad, Z.S.H., Krumholz, H.M., Leskovec, J., Topol, E.J. and Rajpurkar, P., 2023. Foundation models for generalist medical artificial intelligence. *Nature*, 616(7956), pp.259-265.

Issues with current systems

1. Trustworthiness - ChatGPT provided responses that contain factual errors, unethical responses that can affect people's' life. [1]
2. Explainability
3. Data quality and fairness [2]
4. Lack of data visualization and availability
5. Security and privacy

1. Wu, J., Gan, W., Chen, Z., Wan, S. and Lin, H., 2023. Ai-generated content (aigc): A survey. *arXiv preprint arXiv:2304.06632*.
2. L. Bertossi and F. Geerts, "Data quality and explainable AI," *Journal of Data and Information Quality*, vol. 12, no. 2, pp. 1–9, 2020

Solution



Tools and websites

1. Hugging Face (find LLMs, datasets, etc.,)
2. UK Biobank (Health Research Database)
3. Physionet (The Research Resource for Complex Physiologic Signals)
4. Google Colab (run code in clouds)
5. Kaggle (learn from others' code, and run code in clouds)
6. GitHub

Journals

Journal Name	Publisher	Impact Factor	Category
Nature Biomedical Engineering	Nature Portfolio	26.8	Q1
IEEE Transactions on Biomedical Engineering	IEEE	4.75	Q1
IEEE TRANSACTIONS ON MEDICAL IMAGING	IEEE	10.6	Q1
MEDICAL IMAGE ANALYSIS	Elsevier	10.7	Q1
IEEE Transactions on Microwave Theory and Techniques	IEEE	4.1	Q1
IEEE Transactions on Neural Networks and Learning Systems	IEEE	10.2	Q1