AI AND THE THYROID

How Sally can help both patients and healthcare providers

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Our Solution

Most issues associated with the thyroid gland (specifically related to thyroid hormone), either primary (meaning due to thyroid pathology) or secondary (meaning due to hypothalamus or pituitary gland pathology), are chronic disorders. Thanks to recent medical advancements, many treatment options are available for those with such disorders, however, they often include medications for life and logically require consistent check-ups from healthcare providers. Such check-ups are time-consuming for both the patients and healthcare providers.

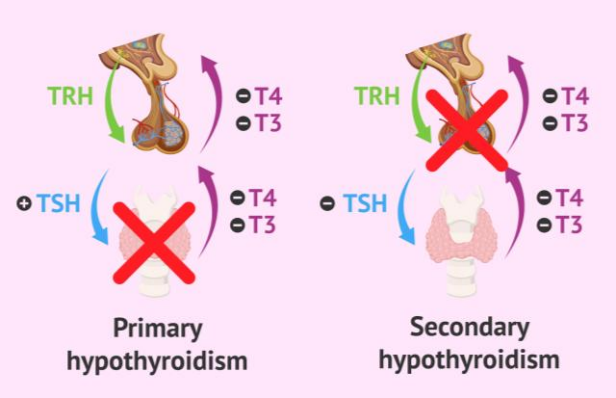


Figure 1 Ex. Primary vs Secondary Hypothyroidism

To best understand our product and its wider applications, imagine someone being treated for hyperthyroidism, possibly due to Graves' disease. Their eyes may be bulging, they may feel hot, and anxious, and they may have other uncomfortable or possibly embarrassing symptoms, such as exophthalmos. It is unlikely that the patient has any desire to leave their home for a clinical checkup. On the other hand, consider the overworked physician. They had a swarm of patients one day, stayed at work much later than planned, and still wanted to come home and make time for their children and partner, though they had pushed off a patient check-up call until the end of the day. A delayed check-in, when the physician is fatigued, stressed, and does not have the time for such a formality, is unlikely to yield a net positive result. It is likely a physician in such a case will not ask all the proper questions, may not provide the respectful and diligent care of their usual standard, and will possibly improperly compile the information they have gathered.

Our product, which we call *Sally*, provides a solution to both (**our tool provides help to both the patient and the physician**). Simply put, our product is an automated personified chat-bot for long-term symptom tracking of chronic illnesses. The automated call, however, is not robotic or static, but rather fluid, and much closer to a realistic conversation using *Twilio* and *Open Ais Real Time API*. Its function is to replace the "check-

up call" from the physician, specifically for patients who may be at risk of thyroid disorders, or patients currently being treated for thyroid disorders. It has been prompted to ask specific questions, based on the cases provided, and extends (in theory) to all possible thyroid cases. Once the call is complete, the data is tabulated and sent to the physician in the form of a standardized email – listing the answers to the general guiding questions and additional information provided by the patient in an organized manner. Once again, the product:

- Calls the patient (at a set time and date) – **removing the patient's responsibility** for going to see a physician.
- **Interacts with the patient** in a kind, human-like manner.
- Is programmed to **ask specific questions** (as related to symptoms of thyroid disorders), though it is **flexible** in question order and responses.
- **Summarizes patient responses** in a standardized manner in an email directly to the physician.

Saves time, and energy, for both the patient and healthcare provider.

Understanding the Problem & Justification

It is important to mention that this tool of ours is **not a diagnostic device**. This tool was made to check up with patients at risk of thyroid disorder, or those already flagged and being treated for a thyroid disorder. With that in mind, the medical factors that were used to create the questions asked by the product are **general** in their nature. None can be said to be "tell-tale" signs of specific thyroid conditions to the unbiased physician, who is not specifically looking for thyroid issues as we are (this bias is addressed in the Biases section of the report), however, our guiding questions make note of specific biomarkers and symptoms generally associated with such conditions. These medical factors include:

- Changes in weight
    - And as such, changes in diet or exercise patterns
- Changes in body temperature
    - Has the patient been feeling warmer or cooler lately?
- Possible neck pain
- Changes in skin
    - Discoloration?
    - Dry? Wet?
    - Pale?

- Changes in nail composition
- Diet
- Noticeable heart rate changes
- Changes in bowel movement
    - Have they been frequent or not? Loose or constipated?

Note how one does not have to be a healthcare professional to be well informed about the above medical factors. They are highly personalized, general, and can be answered by an “inexperienced patient” (unexperienced with respect to thyroid knowledge).

Though the medical factors are simple, they are internationally so, they are created with imbalances in thyroid hormone in mind, and based on symptoms directly associated with thyroid issues. One with hyperthyroidism may find themselves losing weight, even if they eat often, feeling hot (due to increased metabolic activity), and may have frequent loose stools (once again due to increased metabolic activity. With high TH (thyroid hormone) levels, the body increases rate of digestion. As such, stools are more common, and possibly not properly formed, and hence loose). One with hypothyroidism may notice weight gain, even if they are not eating much, and are exercising (due to decreased metabolic activity). They may also experience noticeable changes in the composition of their skin (since thyroid hormone directly affects the rate at which skin cells regenerate). People with hypothyroidism may report dry, scaly skin, as a result of reduced skin cell turnover, and increased keratin production. People may also report puffiness in the face and forelimbs, due to the increased water retention associated with hypothyroidism.

The data collected on the call **allows the healthcare provider to examine the patient's information** and determine possible diagnoses or further courses of action.

Resources and Code

- **Twilio**: We utilized Twilio to handle voice calls and media streaming.
- **OpenAI Realtime API**: We used OpenAI's Realtime API to process real-time voice interactions.
- **Ngrok**: We leveraged Ngrok to create an HTTP tunnel and expose our local server.
- **OpenAI GPT-4o**: We utilized GPT-4o to generate email summaries based on patient interactions.

- **FastAPI**: We implemented FastAPI to manage HTTP requests and WebSocket connections.
- **WebSockets**: We used WebSockets to facilitate real-time communication between Twilio and OpenAI.
- **SMTP (smtplib, email.mime)**: We utilized SMTP to send automated email reports.
- **Python Libraries Used**:
    - os: We used os to manage environment variables.
    - json: We utilized json for data serialization.
    - base64: We leveraged base64 to encode and decode audio data.
    - asyncio: We used asyncio to manage asynchronous tasks.
    - websockets: We implemented websockets to manage WebSocket connections.
    - dotenv: We used dotenv to load environment variables.
    - twilio.twiml.voice_response: We leveraged this to generate Twilio Voice Responses.
    - fastapi.responses: We used fastapi.responses to handle API responses.

To view the original prompt engineering fed to *Sally*, click here. Note that this prompt led to some latency in responses, and was later condensed using Chat GPT.

Ethical Considerations and Bias Handling

Biases:

As team members of this hackathon, it is clear to us that we are coming at the challenge with a bias, that being: the knowledge that the patients at hand have thyroid-related issues. We did not want this bias to be reflected in our work. As such, we did not create a tool that diagnoses patients with thyroid conditions. Rather, we created a tool that will aid the physician in the identification of possible thyroid conditions and help the physician check up on patients who have already been flagged (by the physician) as at risk for thyroid disorders, or patients who are currently being treated for thyroid disorders. The questions asked by our product are general and do not necessarily provide concrete evidence for diagnoses. This evidence would be found by the physician, using, for example, a blood test

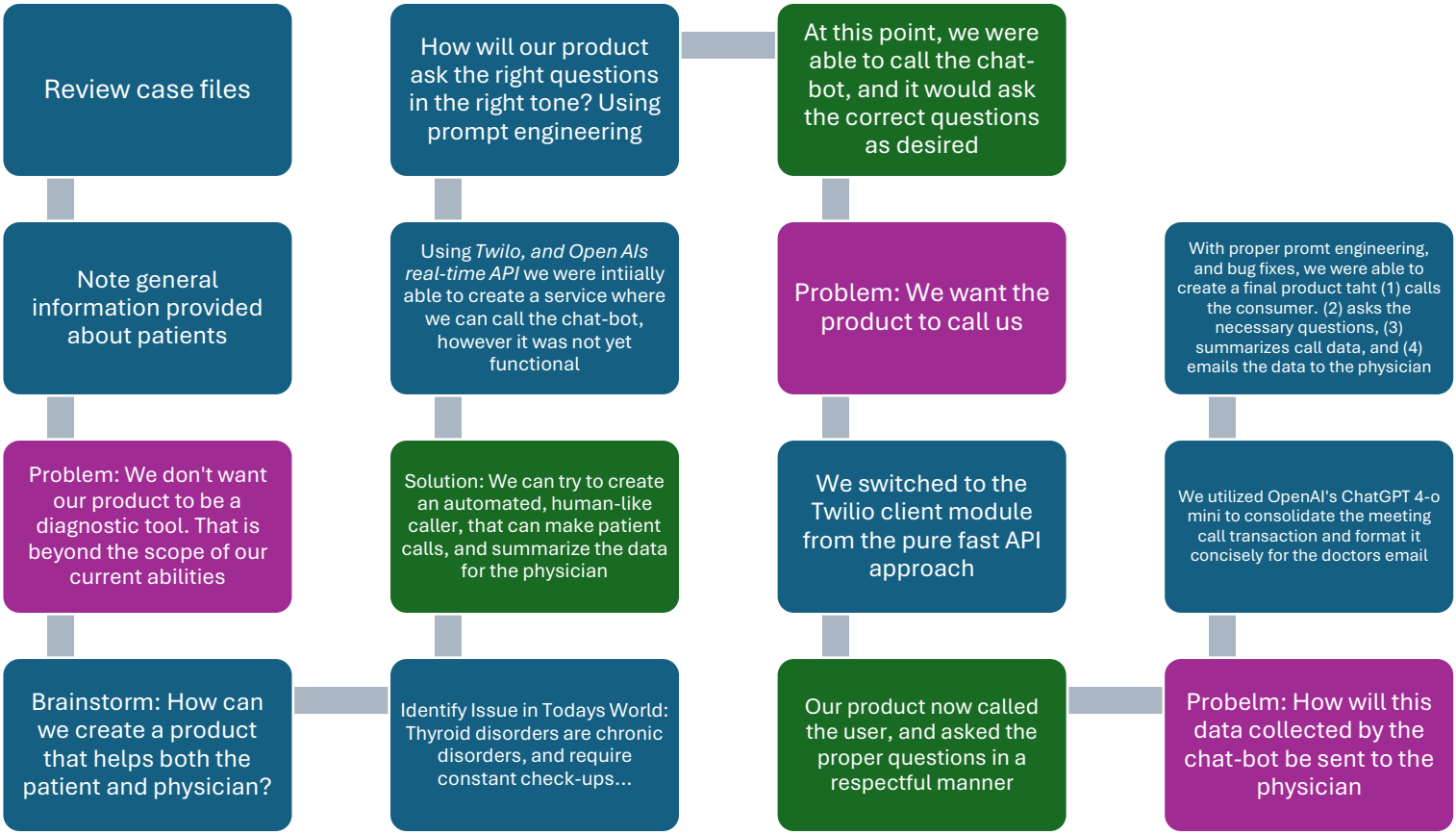
for thyroid disorder (e.g. testing for TSH levels, free T4, T3, etc.). Our product simply outlines symptoms associated with thyroid disorders and organizes these symptoms for the physician. With this in mind, we cannot outline any clear biases associated with our tool. If it is applied to the appropriate users outlined previously, and not with goals of diagnostics, our product does not show any specific biases.

Ethics:

Considering that our product is one that calls a patient, collects personal medical data, analyses said data, and sends an email to the patient's physician, it is clear **that privacy and security are of great importance to such a tool**. Generally speaking, it would be important that our tool runs on the servers of the hospitals themselves. This alone decreases the chance of data breach and interception. Further security measures that would be required for our product are beyond the scope of what we are presenting today, however, **we understand that these measures will have to be established**. Such tools are currently available and in use today. Simply consider how secure one feels with their banking information on banking apps, or with the messages they send through established services, like WhatsApp or Instagram.

Process of Creation:

(neutral, problem, solution)



Conclusions and Future Work

Key Takeaways from the Project

In this short time, we had to dissect patient cases, brainstorm a final product, produce a functional tool, overcome multiple errors in the production process, and summarize our process in a digestible manner. Though we only had 8 hours for this project, we learned an immense amount, with respect to the Python language itself, manipulating language models already available to the public to fit our specific needs, and the complexities involved in sorting data when said data is case specific, not necessarily well-organized, and possibly ambiguous (this data being the health data provided to us in the case files).

If we had one main takeaway from our project today, it would be the challenges associated with producing an AI model that can be used for diagnostics. Such a tool would require immense amounts of data, computational power, and time, all of which are not currently available to us. As such, we determined that, considering what is at our disposal, the current applications of consumer-available large language models and GPTs are to **AID**, and act as "**helpers**" to diagnosticians (human physicians) already working and specialized in their field. This takes advantage of the rigorous work put into, and skillset provided by the AI models already widely available and has the potential to streamline medical diagnostic processes by exponential factors (this answers why we relied on external AI models, rather than creating our own). We believe the product we have provided today is only skimming the surface of what is possible when AI and medicine come together. More on this in the next section: *How can the work be improved or expanded?*

How can the work be improved or expanded?

The tool created can be improved and expanded in a variety of ways – all of which are a matter of time allotted for such expansions.

- Consider, for example, the applications this tool can have for communities in developing countries. With the proper time and resources our tool can have the ability to converse in multiple languages.
- Consider the applications this tool has for elderly health checkups. It allows for medical check-ups for elderly or the physically disabled at the comfort of their own home.
- Consider the applications this tool may have beyond the scope of thyroid conditions. As of now, it has been prompted to ask leading questions with respect to disorders such as hyperthyroidism, hypothyroidism, and associated disorders, however with large enough data sets and guidance from healthcare professionals, this can be applied to a wide range of medical issues, all around the world.
    - For example, if our tool was paired with another. The latter is able to scrape through patient data, flag specific possible conditions, or people at risk for possible conditions, and then our proposed tool calls said patients and asks specific guiding questions. It can then organize this information in the same manner outlined above.

With the proper time and resources, our product can be expanded to a wide variety of conditions, for patients worldwide.

Video Trial of the Product

We have decided to test our product on Patient Case #5, Aisha K (with some changes to her symptoms). It was noted that she has lost some weight recently, has been restless and nervous, had building eyes, and recently had a panic attack. Given the proper tools, she would be automatically selected for a thyroid check-up, given her past medical history and family history. To see how Sally, our automated chatbot, handles the nervous patient, click the link below:

Link to Product Video

Note how Sally (our product) does not diagnose our patient, Aisha. Sally "simply" asks specific questions based on the medical factors outlined in the *Understanding the Problem and Justification* section. It then creates a summarized report for the physician as outlined in the original prompt engineering (pages 6-8).

Sources

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Also used sources listed under *Resources and Code*