LBA: Expert System Design using Prolog

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Background

In the wake of the COVID-19 pandemic outbreak, there are a lot of uncertainties and misinformation, which give rise to the need for quick information and accurate decision making. With the global rotation being the defining feature of Minerva, the students must take decisive action on their health status and travel plan as the situation becomes severe every passing day. For these reasons, we design an expert system that gives a preliminary assessment in case the person has symptoms and suggestions regarding contact points and medications in case the person is having health issues.[1]

The askables will be about the symptoms and possible medical allergies:

- Whether the person has a high (i.e., higher than 36.6° Celsius) body temperature?
- Whether the person has shortness of breath?
- Is the person coughing?
- Is the person's nose runny?
- Whether the person has itchy eyes?
- Does the person have a sore throat?
- Does the person have an uncomfortable chest?
- Is the person sneezing?

And if the person is suggested to take some medications, the expert system will ask an additional question, such as "Are you allergic to Acetaminophen/Ibuprofen/Antihistamine?" Based on the symptoms and allergic history, the expert system can recommend medication to alleviate the symptoms.

[1] **#rightproblem**: accurately identified the initial state (i.e., state of misinformation, students in need of advice), goal state (i.e., getting a self-assessment and some reliable information about COVID-19), obstacles (i.e., lack of information, uncertainty), and scale (i.e., Minerva students, as we travel a lot, are currently in need of help, which is a good scale for a two-week project).

Data Collection

Our knowledge base is from the following infographic released by The University of Alabama at Birmingham, Department of Medicine (Pope, 2020). Some other sources we consulted are from medicine.net or webmd.com. Detail links are in the reference section[23].

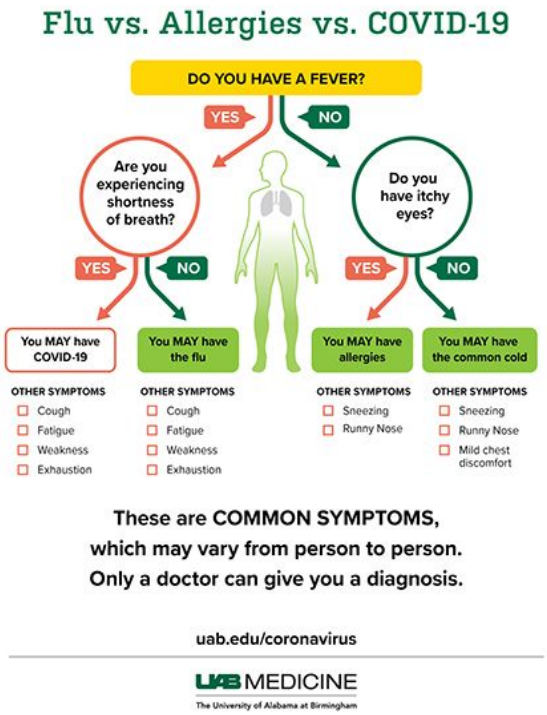

Figure 1. Disease identifier (Pope, 2020)

For the contact information, we know that many of the students left in San Francisco still live in Minerva residential hall (i.e., around 25 people) and are under GeoBlue insurance coverage. The address for Minerva residential hall in San Francisco is 16 Turk Street, San Francisco, CA 94102. Based on that address, we went on to GeoBlue to find the closest recommended hospital to the residential hall, which is California Pacific Medical Center Van Ness campus.

[2] **#sourcequality:** given the context of uncertainty and lack of reliable information, used the most appropriate, highest quality sources from among potential sources (i.e., Medical University articles, etc.)
[3] **#evidencebased:** we supported the decisions suggested by AI with information obtained from reputable sources and available data.

Implementation[4]

The below table represents which values of askables lead to specific information provided to the user about the fundamental problem they have. The − mean that no specific information about these symptoms should be provided. The $\checkmark_1$ means that they should be true for the first rule provided in the KB, and subsequently, the X_1 means that this symptom should not be present for the same rule. The subscript represents the rule number for which the symptoms should be present/absent. The X means that if that symptom is present, it is automatically not that type of disease.

Symptoms/Disease	**COVID-19**	**Flu**	**Common cold**	**Allergy**
High body temperature	$\checkmark_1$	$\checkmark_2$ $\checkmark_3$	$X_1 X_2 X_3$	$X_1 X_2$
Shortness of breath	$\checkmark_1$ $\checkmark_2$	$X_1 X_2$	X	−
Dry cough	$\checkmark_2$	$\checkmark_1$	−	−
Runny nose	−	$\checkmark_3$	−	$\checkmark_2$
Itchy eyes	−	−	X_3	$\checkmark_1$
Sore throat	−	−	$\checkmark_1$	−
Chest discomfort	−	−	$\checkmark_2$	−
Sneezing	−	−	$\checkmark_3$	−

The below table represents which values of some askables and found problems lead to specific information provided to the user about the medications they need to take. The notation is the same as in the above table.

Information/ Medicine	**Cough Syrups**	**Anti histamines**	**Acetaminophen**	**Ibuprofen**	**Medicine from doctor**
COVID-19	−	−	−	−	$\checkmark_1$

[4] #**algorithms:** we employed an algorithmic approach to solve this decision problem.

Flu	–	✓$_1$	✓$_1$	–	–
Common cold	✓$_1$	–	–	✓$_1$	–
Allergy	–	–	–	–	✓$_2$
Dry cough	✓$_1$		–	–	–
Runny nose	–	✓$_1$	X_1	–	–
Acetaminophen allergy	–	–	X_1	–	–
Ibuprofen allergy	–	–	–	X_1	–
Antihistamine allergy	–	X_1	–	–	–

The below table represents which values of some askables and problems found, as well as information about whom to contact, lead to specific information provided to the user about the places they need to contact immediately. The notation is the same as in the above table. The ✓ means that the information should always be true to contact that specific entity.

Information/Contact	**Minerva**	**Hotline**	**Hospital**	**Insurance**
High body temperature	✓$_1$	–	–	–
COVID-19	–	✓$_1$	✓$_1$	–
Flu	–	–	✓$_2$	–
Allergy	–	–	✓$_3$	–
Common cold	–	–	✓$_4$	–
Hospital	–	–	✓	✓$_1$

The expert system begins with asking the user about any possible symptoms. The questions to be asked by the expert system will be in the order: whether the person has high body temperature, shortness of breath, is coughing, has a runny nose, itchy eyes, sore throat, uncomfortable chest, is sneezing and has any medication allergies in case the expert system is going to suggest some medicines. The expert system asks questions in this order because the

expert system wants to detect the symptoms of the most dangerous disease right now (COVID-19) then milder diseases such as a common cold. Once all inputs are received, the expert system will return its diagnosis, some contact points (such as Minerva staff, Geoblue-insured hospitals, insurance, and COVID-19 hotline).[5]

Extensions

We implemented all three extensions.

- **Extension 1**
    - For the first heuristic, instead of requiring to type the full answers manually to each of the questions, we made it easier for the user to navigate through the questions by adding a menu-based response system. The user needs to choose the most appropriate answer and just type the number of the option.
    - For example, instead of typing "yes" or "no" to the question, "Do you have a high body temperature?" users can choose from two options - "1. Yes, I do" and "2. No, I don't have a high body temperature" by simply typing 1 or 2.
- **Extension 2**
    - For the second heuristic, instead of putting everything in a simple "attribute is value" form, we have tried to present the queries in more natural language, although it could be further developed.
    - For example, instead of writing, "body temperature is high," we have "Do you have a high body temperature?" which sounds more natural. Another example could be the way we present the contacts - instead of writing "contact is insurance," we write that "You should contact insurance."

[5] **#ailogic:** we formulated the needed predicates in a way that addresses the relevant problems given their natural language meanings when creating the KB (i.e., rules, askables, etc).

- **Extensions 3**
    - We have a graphical user interface rather than a text-based one, which runs on Python's Tkinter module. Although it might look a little "ugly" because of the module features, it works fine for the basic needs. We could also improve the GUI implementation by using a different library (e.g., kivy) or extending the current use of Tkinter to fit the design requirements.
    - We also have a menu based response system, but instead of requiring the users to enter the option numbers or typing up everything in the full word, we have Yes/No buttons. By clicking on the most appropriate option, the program takes this as a response and passes it to Prolog then to run the queries. This saves time and only requires users to click on the buttons.
    - We have an information button (as well as “submit” and “reset”), which explains how to use the system and gives definitions in case words are not familiar.

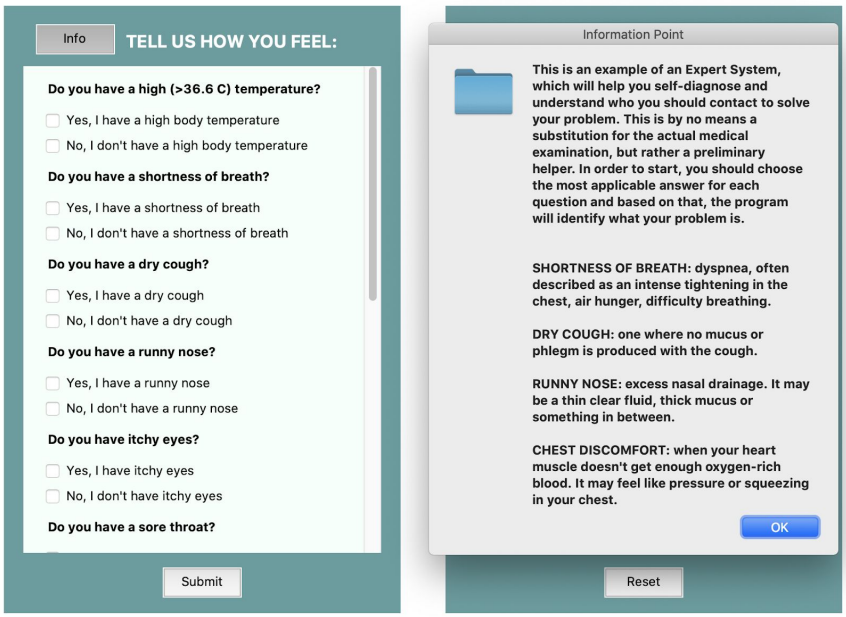

Figure 2. Information button

- **Small limitations:**

- You can tick both yes and no boxes, but the system only registers the last answer (for example, if you tick no last, then the system will register the “no" answer);
- You can submit the answers without even answering all of the questions, and the system will automatically take the empty answers as “Yes;”
- In future, we could potentially improve it but given the time limit, the priority was to make it work for the basic implementation. The fix for the problems above should be trivial.

Test Cases

We can take instances of three different people with a variety of symptoms.

Symptoms	**Person 1**	**Person 2**	**Person 3**
High body temperature	✓	*X*	✓
Shortness of breath	✓	*X*	*X*
Dry cough	*X*	✓	✓
Runny nose	*X*	*X*	✓
Itchy eyes	✓	✓	*X*
Sore throat	✓	*X*	*X*
Chest discomfort	*X*	✓	✓
Sneezing	✓	*X*	*X*
Ibuprofen allergy	✓	*X*	*X*
Acetaminophen allergy	*X*	*X*	✓
Antihistamine allergy	✓	✓	X

This is how it works for the basic approach. Since we employ a deterministic logic-based model, the outcome will be the same for the same input. However, this has a flaw of the actual

symptoms tending to be unclear compared to what the expert system asks for. In such cases, the expert system should employ some fuzzy logic or even the ability to forget wrong answers when the user provides contradicting answers. The accuracy of the answers the system provides will be dependent on the accuracy of the inputs or how well the user understands the questions.

```
Do you have a high body_temperature? yes
Do you have a shortness of breath? yes
Do you have a dry cough? no
Do you have a runny nose? no
Do you have itchy eyes? yes
Do you have a sore throat? yes
Do you have a chest discomfort? no
Do you have a sneezing problem? yes

Your problem is covid.
You should contact minerva, hotline, hospital, insurance.
You should take medication that the doctor prescribes.


MINERVA :  +1 (415) 519-1560 (RA duty phone)

HOTLINE :  833-544-2374 (statewide COVID-19 hotline) or 211
(community services and support), or 911 (emergency)

HOSPITAL :  California Pacific Medical Center Van Ness Camp
us, 1101 Van Ness Ave, San Francisco, CA 94109. Phone: +1
(415) 600-6000

INSURANCE :  globalhealth@geo-blue.com
```

Figure 3. Output for Person 1

```
Do you have a high body_temperature? no
Do you have a dry cough? yes
Do you have a shortness of breath? no
Do you have itchy eyes? yes
Do you have a runny nose? no
Do you have a sore throat? no
Do you have a chest discomfort? yes
Do you have a sneezing problem? no
Are you allergic to acetaminophen? no
Are you allergic to ibuprofen? no

Your problem is flu, or allergy, or common cold.
You should contact hospital, insurance.
You should take cough syrups, acetaminophen, medication
that the doctor prescribes, ibuprofen.


HOSPITAL :  California Pacific Medical Center Van Ness
Campus, 1101 Van Ness Ave, San Francisco, CA 94109. Pho
ne: +1 (415) 600-6000

INSURANCE :  globalhealth@geo-blue.com
```

Figure 4. Output for Person 2

```
Do you have a high body_temperature? yes
Do you have a shortness of breath? no
Do you have a dry cough? yes
Do you have a runny nose? yes
Do you have itchy eyes? no
Do you have a sore throat? no
Do you have a chest discomfort? yes
Are you allergic to antihistamine? no

Your problem is flu.
You should contact minerva, hospital, insurance.
You should take antihistamines.


MINERVA :  +1 (415) 519-1560 (RA duty phone)

HOSPITAL :  California Pacific Medical Center Van
Ness Campus, 1101 Van Ness Ave, San Francisco, CA
94109. Phone: +1 (415) 600-6000

INSURANCE :  globalhealth@geo-blue.com
```

Figure 5. Output for Person 3

We are modeling the responses of an expert in the field (i.e., a healthcare professional) when a patient walks into the hospital. Given the current situation with the coronavirus, we think that the order in which we assembled the KB will resemble the way the doctor will intuitively try

to diagnose the patients as we understood from the different articles we have read shown in the references.[6]

Below are the test cases for the extended version of the expert system with an additional menu-based response system divided into two screenshots for each.

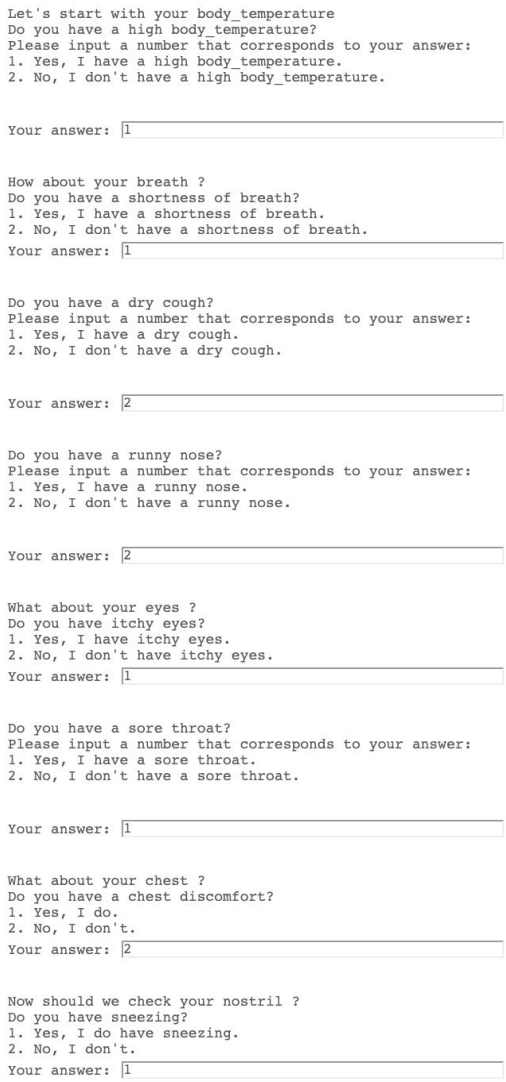

Figure 6. Output for Person 1 (1)

Figure 7. Output for Person 2 (1)

The system works the same way for the third person and gives the same response as the one presented in Figure 3 above.

[6] **#modeling:** accurately created a model that can describe a system (i.e., modeling the suggestions of a healthcare professional through the expert system); accurately determined the relevant aspects of a model in a given context (e.g., deterministic model).

```
Your problem is covid.
You should contact minerva, hotline, hospital, insurance.
You should take medication from doctor.


MINERVA :  +1 (415) 519-1560 (RA duty phone)

HOTLINE :  833-544-2374 (statewide COVID-19 hotline) or 211
(community services and support), or 911 (emergency)

HOSPITAL :  California Pacific Medical Center Van Ness Campus, 1101
Van Ness Ave, San Francisco, CA 94109. Phone: +1 (415) 600-6000

INSURANCE :  globalhealth@geo-blue.com
```

Figure 8. Output for Person 1 (2)

```
Are you allergic to acetaminophen?
Please input a number that corresponds to your answer:
1. Yes, I am allergic to allergic.
2. No, I am not acetaminophen to allergic.


Your answer: 2


Are you allergic to ibuprofen?
Please input a number that corresponds to your answer:
1. Yes, I am allergic to allergic.
2. No, I am not ibuprofen to allergic.


Your answer: 2

Your problem is flu, allergy, common cold.
You should contact hospital, insurance.
You should take cough syrups, acetaminophen, medication from doctor,
ibuprofen.


HOSPITAL :  California Pacific Medical Center Van Ness Campus, 1101
Van Ness Ave, San Francisco, CA 94109. Phone: +1 (415) 600-6000

INSURANCE :  globalhealth@geo-blue.com
```

Figure 9. Output for Person 2 (2)

As seen from the above screenshots, the menu-based system gives the user two options and presents them in natural language. The user has to choose the most appropriate option and enter a number corresponding to that answer.

Below is the GUI representation and the test cases run on it. The results are the same for all implementations.

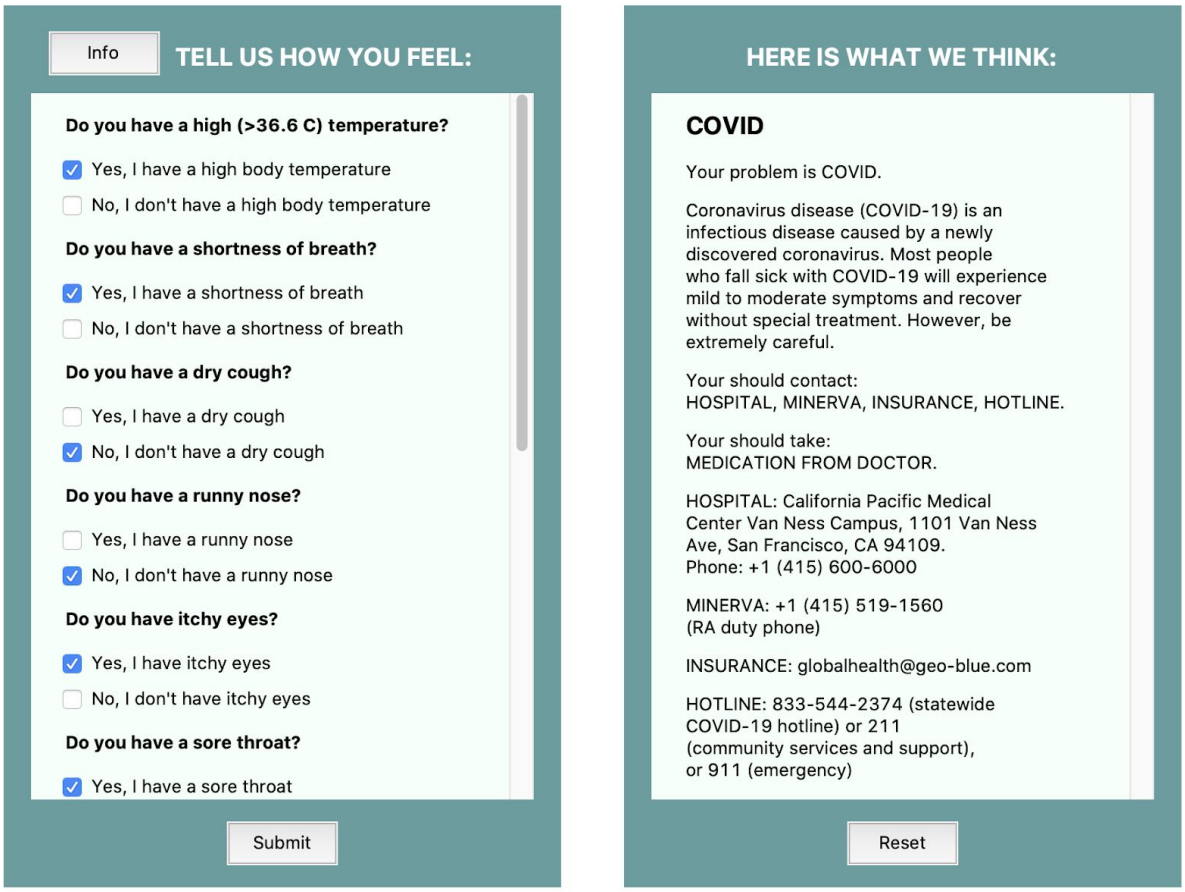

Figure 10. Output for Person 1

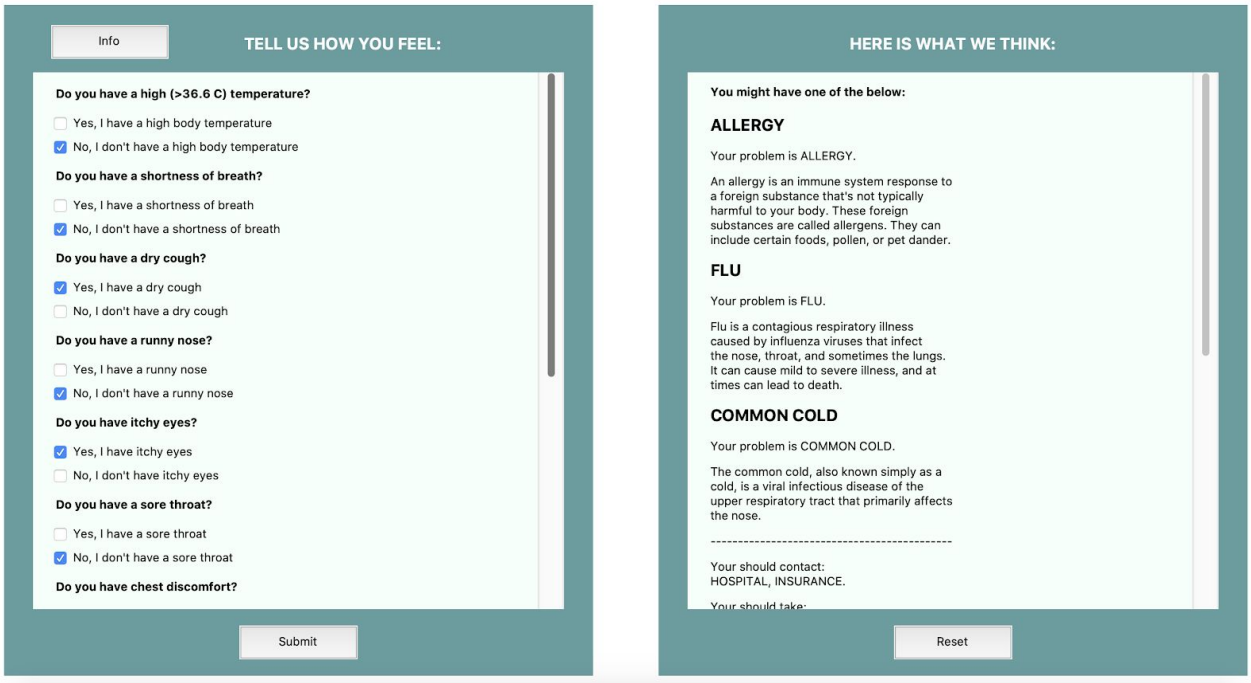

Figure 11. Output for Person 2 (1)

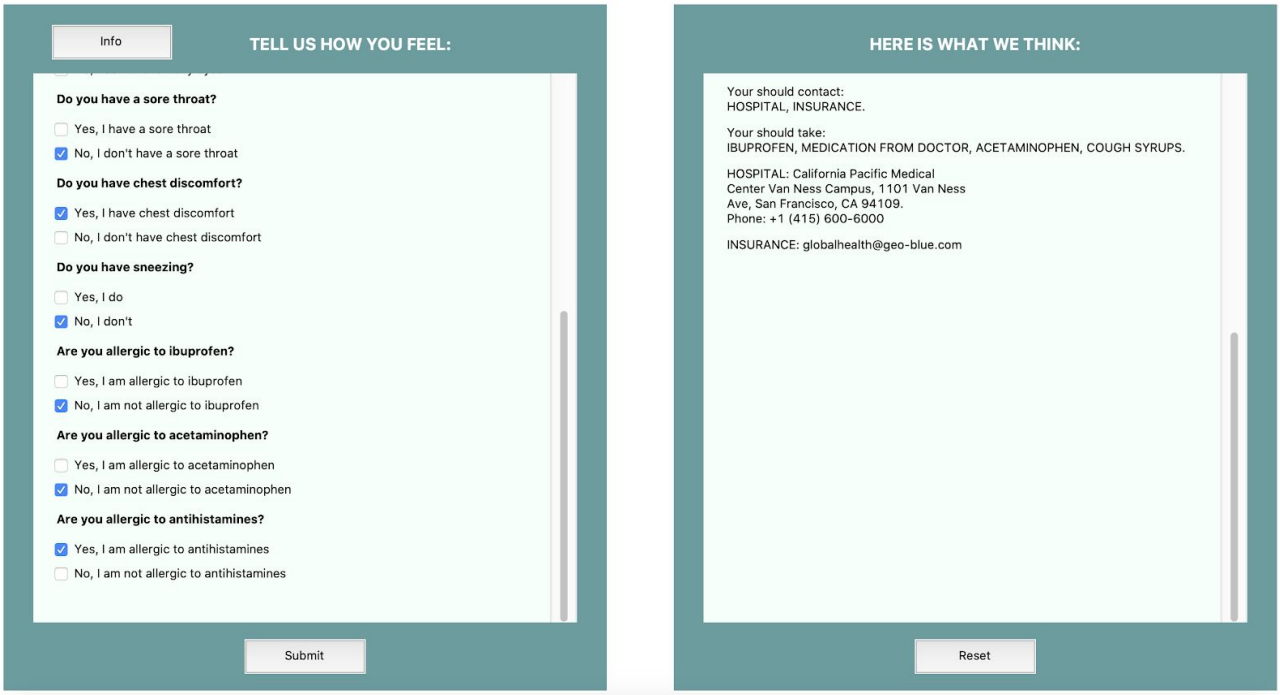

Figure 12. Output for Person 2 (2)

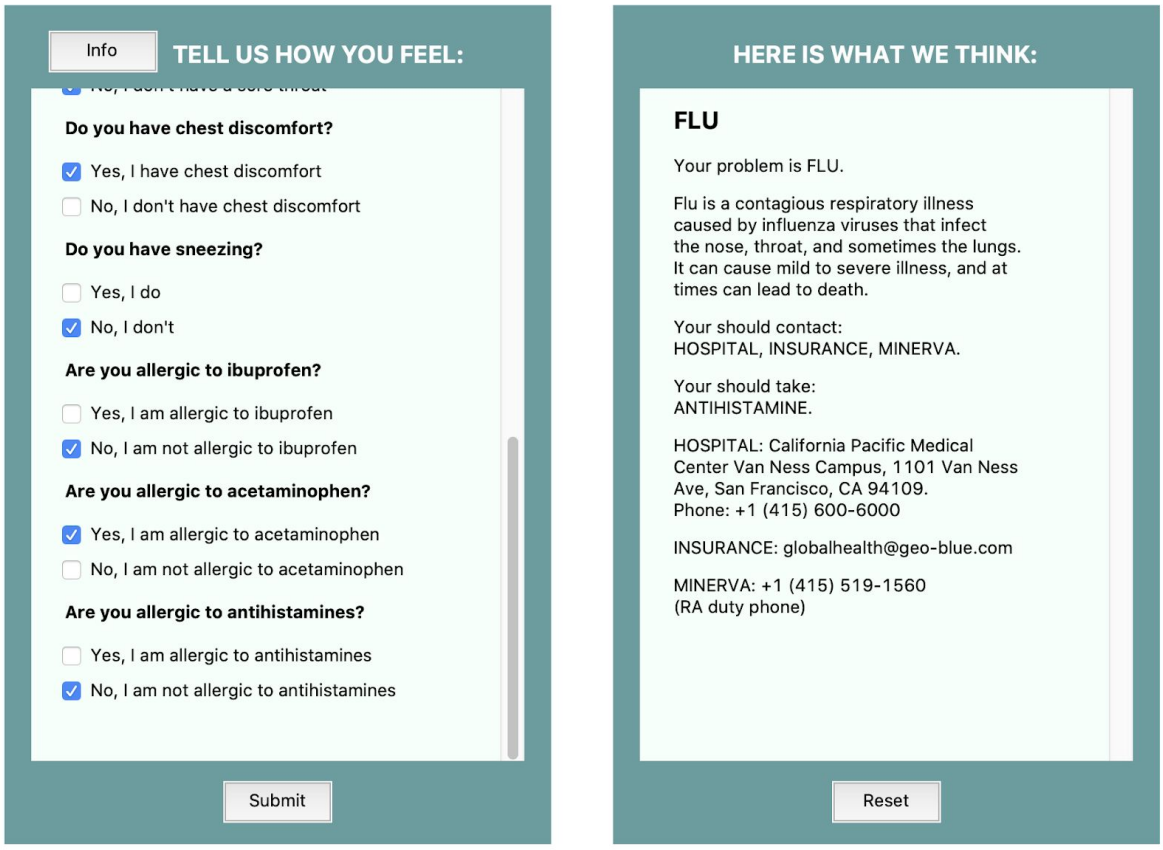

Figure 13. Output for Person 3

Conclusion

The expert system outlined here is by no mean a substitute to an actual diagnosis by physicians. However, the system is still helpful to Minerva students who suspect that they may have been infected with coronavirus by giving a preliminary assessment. The student is also given guidance on whom to contact and which medication they should take to alleviate their symptoms. We can also improve this expert system by:

- Add more detailed questions regarding the duration of symptoms, their severity, medical history of the users, etc.;
- Add neighborhood information to our knowledge base to recommend the closest hospital;
- Add more disease possibilities for more complex diagnosis;
- Add questions on the nationality of the user and the intended travel plan to check for possible travel bans, visa restrictions, or flight schedules.

A medical expert system should have that information to be used in general cases (not Minerva-specific or COVID19 -specific). Due to a time constraint and lack of medical expertise, the expert system presented here is limited in functionality. However, using the same principles and similar processes, a more sophisticated expert system could be built based on this prototype.

Contribution

- Hoang designed the KB, Vy and Akma implemented code for the expert system, and Akma made the GUI. All group members contributed equally in the process of ideation and writing this report.

References

Davis, MD, PHD (2020). What are the differences and similarities between the common cold, flu, and COVID-19 (2019 novel coronavirus)? Retrieved from: https://www.medicinenet.com/covid-19_vs_flu_vs_cold/article.htm

Pope, A. (2020). Sorting out symptoms of COVID-19, influenza, colds and allergies. UAB Medicine: The University of Alabama at Birmingham. Retrieved from https://www.uab.edu/news/youcanuse/item/11179-sorting-out-symptoms-of-covid-19-influenza-colds-and-allergies.

WebMD. (2020). Better Information - Better Health. Retrieved from https://www.webmd.com/.

Wikipedia contributors. (n.d.). Wikipedia. Retrieved from https://github.com/AshNguyen/CS152-LBA.

Appendix

The code was submitted as an additional file, but you can also find it on Github here.