Know Your Diseases!

Kashyap Bhansali

Graduate Student  
Computer Science (MCS)

Arizona State University

[Kashyap.bhansali@asu.edu](mailto:Kashyap.bhansali@asu.edu)

Saloni Shah

Graduate Student  
Computer Science (MCS)

Arizona State University

[Saloni.shah@asu.edu](mailto:Saloni.shah@asu.edu)

Raj Dalvi

Graduate Student  
Computer Science (MCS)

Arizona State University

[rsdalvi@asu.edu](mailto:rsdalvi@asu.edu)

**ABSTRACT**

Visual analytics is a kind of analytics in which the data is showcased visually displaying analytical results and insights extracted from large, complex dataset. Intelligent Visual Analytics is not only about showing statistics using charts but also involves text processing using text mining and Information Retrieval to represent important information visually. ‘Know your diseases!’ is one such kind of intelligent visual analytics. In this paper, we describe the analytical system in it’s entirety, ranging from the visualizations displayed and the principles involved behind its selection. The data from Q/A portal called WebMD is processed, cleaned and visualized to not only look aesthetically pleasing but also to convey the information visually. The goal of this system is to convey information to the fullest and consequently, encourage users to interact with the system to gain utmost knowledge about the diseases.

**Keywords**

Health Data Visualization, Visual Analytics, Medical analysis.

# INTRODUCTION

The essential essence of a visualization lies in effective narration of a tail. Vision is the most operative and powerful faculty to relay information from a large scale of data, which when represented by text or a data table, does convey a tail, but limits our perception of the information.  It is important for intelligent visualizations to answer questions, support decisions and communicate information [1]. Today, one of the richest sources of information on public opinion are discussion forums found over the web.[2] Therefore, we have developed an Intelligent Visual Anayltics for one such forum pertaining to health and nutrition, WebMD.

Over the years, an increase in health awareness has been realized and therefore there has been a significant growth in the number of users who have started using the rejoining and explanatory forums to gain more information related to health.[3] These forums facilitate easy and convenient solutions to audience’s query in a significantly less time. These systems allow people to interact with other users and share their knowledge related to health. These forums also claim to solve problems of a share of population by answering just one individual’s question. Plethora of such web-forums, that provide remedies to health problems and particulars about diseases, symptoms and drugs, exists today, namely Patent Forum [4], eHealth Forum [5], EBIX A.D.A.M [6] ,etc.

WebMD is primarily an online publisher of news and information relating to human health and well-being. [7] It is widely used as a health forum inundated with a surfeit of symptoms, health concerns and expert advice. We’ve implemented an analytical system which covers a broad expanse of health topics, question-answers, WebMD community member details, and disease details. ‘Know your Diseases!’ lists the most prevalent topics and based on the topic selection, it displays an interactive visualization which shows the relationships between various diseases and symptoms, other related topics, the prevalence of disease over the past years, and reveals the affected region of human anatomy. Overall the idea is to allow the user to get a good overview of what is being discussed, how things are interleaved and also have the ability to get more details on demand from Q&A discussed on the WebMD forums. This analytical system aims at providing a complete analysis of a given disease topic discussed on the forum.

Section 2 describes the motivation behind this system. Section 3 discusses the visual design of the system followed by Section 4 discussing the implementation details. The paper is concluded by enlisting some unusual findings and discussing some future goals.

# MOTIVATION

# “Health is wealth” - There is nothing in our life that is more valuable than good health [8]. A healthy person is completely free from any illness or injury. Therefore, staying healthy and sound is very crucial.

The question and answer portals are modern form of an information exchange system. A study conducted by M. Dolores et al in[7] collects hundreds of definitional question from two health related websites WebMD and MedQA. The retrieved answers were tested for four evaluation measures like precision, mean reciprocal rank, total reciprocal rank and first hit success to check the quality of the answers given by users on this portal. It was seen that these systems are useful to retrieve basic healthcare related information. Some of the answers from MedQA also give links to future research articles. This provides us a simple insight into how a question-answer forum can be a tool providing realm of information access.

Recently, the software firm Intel developed a way to provide personalized care [9] to individuals. The main idea behind this project was to stipulate unique health care information to a patient keeping in mind their situation and needs.  They promise to help individuals to be proactive in deciding which patients are at high risk for readmission into hospital, admission to ICUs and similar other conditions. All of these are powered by their technology and health related DATA.

This heavily inspired us to design an analytical system ‘Know Your Diseases!’ which would assist in speculating health problems based on symptoms and would realize awareness of a disease in terms of its prevalence and related health issues . We aim to provide answers to following research questions: 1.What kind of questions are asked on the forum? What are the most commonly discussed Topics & Diseases? 2. What are the Symptoms people with particular Disease have? What parts of the human body are affected by this Disease? 3. Prevalence of the Diseases in the population over the years? Hence, a better health quotient was aimed at, while designing and implementing ‘‘Know Your Diseases!”

# VISUALIZATION DESIGN

‘Know Your Diseases!’ consists of interesting and informative visuals that helps us answer the research questions in an intuitive way.

It becomes important and challenging to use the right visuals and colors, because large amount of data is being processed and visualized.

We have selected our choice of visualizations based on the Visual Information seeking adage:

* Overview first
* Zoom & filter
* Details on demand

Following are the design principles that we follow:

* Correlation doesn’t imply causation
* Exaggerate or Simplify
* Generalizations improve clarity
* Emphasize important information or de-emphasize irrelevant details

It is important to have a way of revealing several levels of details, from a broad view to a fine structure. It is important in visual analytics to give the user the a number of ideas in the shortest time with the least amount of ink in the smallest space [10][11].

A right color choice improves the perception and makes understanding the data much more convenient. It is also necessary to think how the whole interaction will simulate. In our implementation we have crosslinked the visualizations, i.e. we have coordinated these visualizations in a way where an interaction in one chart will drive the changes in all other charts to reflect that particular interaction.

This system analyses different groups of diseases into an interactive chart showing a hierarchy of health problems. Selecting one bubble subsequently alters the chord diagram to show related symptoms and health diagrams. This helps the user explore his related health problems which he may not be aware of and hence, helps him to analyse his situation better. To facilitate better understanding of diseases under consideration, our human physique highlights the human body area infected and the line chart explains how the disease has been widespread in the past, as per its discussion over the forum. This implementation provides a complete analysis of a disease from the WebMD dataset in its entirety, ranging from symptoms, related problems, and its prevalence in the world.

## Zoomable Bubble Chart

Zoomable bubble charts are basically a big blue bubble that has nested bubbles inside it. This sort of visualization is artistic and quite intuitive when we need to demonstrate a hierarchical structure in data. As the name suggests, this kind of chart will have multiple levels to zoom in. The nature of the bubble also provides one more dimension, that is, the radius of the bubble, which can be used to determine some quantity.

Using the same idea we decided to use a zoomable bubble chart to represents a hierarchy of topics discussed on the WebMD forums.

We clustered a set of topics to build a hierarchy which would help the user to get a good overview and also get to the smallest detail if required. This chart is the driver for the rest of our visual analytics system.

The bubble chart implementation provides a wide taxonomy[3] of health problems grouped into following categories:

* Gender Specific.
* Infants
* Pain
* Hair and Skin
* Drugs
* Hands and legs
* Obesity
* Respiratory Problems
* Food and Drugs
* Sensory Organs
* Stomach, Kidney and Intestines
* Heart Problems
* Sexual Problems
* Surgery
* Blood Problems
* Brain and Spine

The groups have been intentionally named in layman terms so as to facilitate effortless selection. Each big bubble encompasses smaller bubbles, which zoom in on the selection of Parent bubble. Size of the bubble symbolizes the relative number of health complications it categorizes, or the number of.

The motivation of choosing a prescriptive bubble chart for taxonomy was to maintain uniformity in parent and child (representing all the diseases in form of bubbles one inside the other), and to provide easy navigation from one group of diseases to the other.

The radius of the bubble indicates which topics have the most number of discussions. This could help the user to get an overview as to what kind of topics are discussed and their occurrence level on the forum. It makes it easy to drill down to see comparison between individual topics belonging to the same cluster.

Color choices have been made taking into consideration the visualization principles of color and vision. A clear sequential scheme has been used to color the bubbles, cyan ,blue and white (going down the category tree). [4] White color has been used to enhance visualization of the sub-most category in each parent category. Shades of blue have been used because blue symbolizes trust, peace and comfort.

For example, by only looking at the Zoomable bubble chart, we can see and tell the following things:

* there is a lot of discussion about Women health problems accompanied by Q&A’s for General Symptoms like headache, nausea, burns, etc.
* Pain and infection are the most common complications associated with a gamut of diseases.
* Complicated issue like Cancer and Surgery have been less discussed and talked about on the forum, since they’re critical enough to directly consult a doctor in-person.

## Chord Diagram

Chord Diagram is a graphical method of displaying the relationships in data. The data is arranged radially on the periphery of a circle with the related data connected by means of arcs. [12]. This kind of a chart was popularized in 2007 by a post on The New York Times that discussed “Close-Ups of the Genome, Species by Species by Species” [13].

An intelligent chord diagram demonstrates how symptoms and health problems can be linked to other health problems, i.e. the problems which can be simultaneously present or in other words, prevalence of which can make the present symptom into consideration, more probable. All the datasets, especially questions and answer sets have been analyzed to extract all the relations between a gamut of health issues. Figure below is a sample of chord diagram when smaller bubble muscle pain in parent bubble ‘Pain’ is selected.

Nature has created our body in a way that all the organs work together in a  highly coupled fashion. A little malfunctioning in one, results in a complication in other system. For example, a small infection in oesophagus, if left unattended, might result in ulcers of stomach infection. Or in case one has a throat infection, then it may increase the probability of having ulcers. Therefore, for an analysis of a disease, it is very important to obtain related health problems, since it opens new avenues to understand the disease and to find ways to treat it, since treating one problem may help cure the other. Also, in the diagram, a certain chord connects all the problems which have occurred simultaneously together in some other instances.

Different contrasting color options have been selected to display related yet different problems. [10]

## Human Physique

Knowing symptoms, related health problems or broad classification of your problem is not enough if you want to treat your health complication. The most important thing lies in the awareness of the anatomy part where the root of problem resides. For example, patches or rashes in skin, can be caused by the disease dengue, which is a viral attack, most importantly not on the outer visible skin area.

It would be a little unfair to assume that the user of this system would know about all the diseases and symptoms and what areas of the body internally or externally it affects. This encouraged us to add Human Physique diagram to the analytics system which gives a general overview of what areas might be affected with a particular disease.

This particular visualization displays the region in body where the selected bubble effects and realizes pain.

## Line Chart

A line chart is a chart that plots a series of data points, connected by straight line segments [14]. A line chart is often used to visualize a trend in data over an interval of time [15]. Specially in case of the time series data. Thus the line is often drawn in a chronologically order.

In our project we make use of a simple line chart to demonstrate a trend in the prevalence of disease over the years or months. When a topic is selected, this line chart is updated based on the number of questions asked on the forum related to that particular topic over months or years.

A user using our intelligent analytics system could quickly answer if the questions related to certain topics are asked more or less and at around what time of the year. This could help in identifying the trend in symptoms that occur due to change in weather and seasons.

## Relevant Questions and Medical Tests

Should knowing about a disease with respect to its symptoms, related  health problems and prevalence be enough? Yes! But what can be better, than also displaying relevant top questions asked! This section of the analytics dashboard does the same. It displays the most recent questions asked related to a particular topic. The answers to these questions can be read by clicking on it. The question links directly to the WebMD website page where this question was asked, along with extra details like Name of the member posting this question, User ID, question post date, etc. If this member has updated his contact info, he may be contacted by the info-seeking individual who would want to talk to someone who would already have gone through this particular health problem.

Therefore this section sums up entire analysis of a disease by furnishing a direct instance of a disease into consideration. This section thus sums up all the analysis into a link which directs to an occurrence of the disease. It provides a deeper understanding of the same.

Along with symptoms and drugs, we see that relevant medical tests also play an important role in providing information to users. Thus, in our visualization we mention the most relevant medical tests that are discussed amongst the people in question and answers.

# METHODOLOGY

As the starting point for our project, we started diving into the provided dataset. The data about topics, question and answers seemed to be the most important data that drives our visualization. To perform text mining into the question - answers, we scraped additional data from WebMD website. We scraped various symptoms, diseases and drugs. Due to limited number of symptoms collected, we additionally had to extract symptoms from another such medical portal named Mayo Clinic. We used this scraped data to obtain relevant data from topics, question and answer data provided, to be used for our visualization system.

Text Mining involves many different techniques to extract important data from the dataset. For this system, we scraped the data from WebMD datasets and from some other places like Mayo Clinic to draw out the relevant close matches from the questions and answers using sequence matching. Sequence matching has been implemented in python, with a library called ‘difflib’. Sequence matching can be used to match sequences in strings which are hashable. This was preferred over TF-IDF because it reduced the occurrence of meaningless data and also took care of typos which could be there because of the complex spelling of diseases and symptoms. TF-IDF (**t**erm frequency–inverse document frequency) only looks for words in a corpus which it thinks are important but we are not just going for important words. With a bag-of-words approach, some clustering was performed using some manual inputs. A hierarchical structure, was then formed, which has been used to construct a packed zoomable bubble chart.

The bubble chart has various topics and on clicking any of the child bubble, you can see the diseases and connected symptoms in a chord diagram. The bubbles are generalized into topics to improve overall clarity [16]. The size of bubble indicates the amount of times the topics and disease are discussed. For instance, there are maximum number of questions and answers related to Women Health problems followed by Sensory Organs in human body and general symptoms. This helps the user of the system to get a detailed overview of most commonly discussed topics and diseases. The zoom and filter capability help the user to know about the disease and symptoms in the linked chord diagram. More details are provided as the user zooms in to the innermost level of the bubble chart. Thus, the visualization provides complete justice to Visual Information Seeking Mantra taught in class. [17].

Chord diagram was chosen specifically because we wanted our analytics to include displaying the relationship between diseases and their symptoms. A particularly complex dataset can be represented very well using a chord diagram. The chord diagram was created by mapping the topics and their presence in questions and answers datasets. Difflib has a tuning factor which when increased, increases the accuracy but reduces the number of results. Thus, we had to decide a proper tuning factor for both question and answer datasets. We went with 0.6 because it was the ideal factor. The aim in designing the chord diagram is to make large data sets coherent. The chord has multiple colors to show different categories of diseases and a disease and its symptoms are linked together with the same color. Ultimately, as discussed in class, the chord diagram conveys multiple complex ideas with clarity, precision and efficiency. In some cases, the data is not large enough to show a chord diagram in which case a message is put up informing the user that data is not enough to show a chord diagram. At the same time, there might be some topics which are present in multiple questions such as pain whose chord diagram appears really dense.

When a bubble in the chart is clicked on, the chord diagram displays the diseases and symptoms. Apart from that, the affected body part is highlighted in the image of a human body. Here, the diseases affecting either men or women are also present so the bodies of both a man and a woman are present and the affected body parts are highlighted. Majority of the body parts were extracted from the dataset but in some cases, manual inputs were needed to improve the accuracy. Another challenge in this human body usage was to highlight diseases such as diabetes which are not exactly centered on a particular organ of the human body. In that case, the whole body is highlighted or the closest possible body part is highlighted.

The trend of discussion over a particular topic was highlighted using a line chart. The line chart changes for every disease and is interactive with a tooltip present to show the values. This line chart was created by using D3.js and a CSV file containing the topic name, the month-year and the number of times the topic was present at that month-year. The same analysis was done in the question and answer set to get a comprehensive set of information. To generate the CSV, python was used. A progressively rising line chart indicates that the  prevalence of the disease/symptoms increased over the year.

# EVALUATION PLAN

Visual analytics and data visualization are designed for clarity in perception, therefore, we focus on visual interfaces and presentations, which are well understood, based on human biases and on how users interact with computers[18]. Our results are completely based on the questions and answers posted by humans on this forum. These humans are variety of groups ranging from patients, physicians to medical experts. Our results not only will help common people to gain basic knowledge but also health care professionals as they use symptoms and signs as clues that can help determine the most likely diagnosis for a disease. However, proper testing performed by a doctor is recommended to render a diagnosis because many patients experience some symptoms and not others [19].

We apply bottom-up method of processing as discussed in [20]. Firstly, a user extracts information just by having a glance at the analytics dashboard and knowing it showcases medical information without any other thought. The efficiency of this process is related to the large amount of neurons, up to five billion, which are simultaneously processing different features

# DISCUSSION & FUTURE WORK

After successful implementation of the visual analytics, we see that some critical disease like Cancer, Blood problem and the likes have been discussed in less amount as compared to common and minor diseases. This indicates that users do not prefer to discuss critical topics on a forum and would rather choose seeing a doctor in person. We also observed that there is a lot of discussion about Women Health problems followed by Sensory Organs of human body. Pain and infections are the most common complication associated with a gamut of diseases.

After the implementation of showing how diseases and symptoms were related and their behavior over time, we also ought to display the areas in the world affected with these diseases majorly. For this, we digged into the dataset to find data related to geographical location of a user. In the near future, we would add a map visualization showing the occurrence of disease in various parts of the world. We would use choropleth maps showing the country highly affected by the disease in darkest shade and lightening its shade with countries affected relatively less.

This project can be extended into a visual recommender system for health related dataset. After the user enters a symptom, the system would recommend the diseases which commonly see that symptom and vice versa as well. Also, the commonly occurring diseases based on the users’ geographical location would be displayed.

A series of dataset regarding medicines can be collected, hence visualized and consequently recommended by the system. There are so many pharmaceutical companies that manufacture  a same kind of drug. Some medicine produces are instant relief providers and some provide treatment with time. Therefore, an expert/physician has vast amount of choices of medicines to recommend and prescribe. The proposed recommender system can recommend medicines that a doctor can remotely prescribe to a patient, based on the availability of medicine at patient’s location and on how effective that certain drug is, at level of infection or pain.

While discovering about health concerns and related information, we came across Traditional Chinese Medicine (TCM). [21] Our research then made this interesting revelation that TCM has a very effective cure for most of the diseases and health problems. Their traditional and cultural medicines are very relaxing and relief providing. It can be really beneficial for ailing patients to consume this treatment. We aim at popularizing this idea in our recommender system by doing a little more research over this area and  suggesting patients to use this medication if present. This might prove very helpful to the ailing patient.

Another idea we would to be emphasized is accessing the patient’s location and recommending nearby doctors and physician. There are web services [22] avaliable to do the same, but in limited areas. This idea could be embedded into our ‘Know your disease’ and hence a complete essence of a recommender system can be imbibed. What can be better than a system which presents a complete analysis of your system, recommend home remedies, give the user an example of a patient suffered/suffering from the same health problem by means of showing top discussion post, and also recommending to the patient, nearby doctors and physicians.

Why make a system only for the diseased? A normal healthy person should also ensure and maintain his health. A recommending and analytic system should also accompany articles related to health care and healthy lifestyle. An entire section suggesting health and wellness tips and articles can be incorporated into the system. Websites such as Health [23], MedicineNet.com, etc can be embedded. There are so many minor problems a healthy person overlooks. This ignorance may someday cause a big health concern. Therefore maintaining health is very important. ‘Prevention is better than cure’ is what we believe in. An occurrence of chronic fever or a lower abdominal may be a sign of UTI [24]. Initially trivial, this may lead a way for kidney stones or kidney infections which is lethal. Therefore, utmost care is essential.

We might include articles and tips suggesting or recommending exercises to maintain body fitness as well. Anyone may stumble upon some idea that maybe lead to his better health and hence be beneficial.

This is how a simple analytical system ‘Know your diseases’ can be extended in so many multifaceted ways and aid humanity towards better health and fitness regime.

After being acquainted with the basic principles of data visualization and analysis, we would be able to do complete justice to a recommender system for health concerns. Afterall, health is a very critical topic and should be carefully examined and treated.

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# REFERENCES

1. White Paper: Principles of Data Visualization – What We See in a Visual. <http://www.fusioncharts.com/whitepapers/downloads/Principles-of-Data-Visualization.pdf>
2. Mitja T. et Al.Visualization on Online Discussion Forum*s*. Technical Report. University of Maryland at College Park In JMLR; Workshop and Conference Proceedings,2010. <http://jmlr.org/proceedings/papers/v11/trampus10a/trampus10a.pdf>
3. Maria-Dolares et Al. Question-answering systems as efficient sources of terminological information: an evaluation in Health Information & Liraries Journal, December 2010. <http://onlinelibrary.wiley.com/doi/10.1111/j.1471-1842.2010.00896.x/full>
4. <http://www.thepatientforum.com/>
5. [www.ehealthforum.com](http://www.ehealthforum.com).
6. <http://www.healthcaremagic.com/>
7. <https://en.wikipedia.org/wiki/WebMD>
8. Ankita Mitra. An Arcticle: Short paragraph on Health is Wealth in Important India. <http://www.importantindia.com/8847/short-paragraph-health-wealth/>
9. An article: Intel Inside. More Personalized Care Outside. <http://www.intel.com/content/www/us/en/healthcare-it/personalized-care.html?cid=sem43700013298021834&intel_term=analytics+for+healthcare&gclid=CjwKEAiA1ITCBRDO-oLA-q_n8xYSJADjBQfGbJOcLgTZvW-myQ7jV4eL-z9osShcSHXssfRMSI9mDBoCbQzw_wcB&gclsrc=aw.dsv>
10. William C. et Al. Graphical Perception: Theory, Experimentation, and Application to the Development of Grahical Methods in Journal of the American Statistical Association. <http://www.tandfonline.com/doi/abs/10.1080/01621459.1984.10478080>
11. Hadley Wickham. Graphical criticism: some historical notes in Journal of Computational and Graphical Statistics, 2012. <http://vita.had.co.nz/papers/stat-graph-hist.html>
12. <https://en.wikipedia.org/wiki/Chord_diagram>
13. An article: Close-Ups of the Genome, Species by Species by Species. <http://www.nytimes.com/imagepages/2007/01/22/science/20070123_SCI_ILLO.html>
14. Burton G. Andreas (1965). Experimental psychology. p.186.
15. Neil J. Salkind (2006). Statistics for People who (think They) Hate Statistics: The Excel Edition. page 106.
16. Tufte. Data-Ink and Graphical Redesign. In The Visual Display of Quantitative Information. 2010
17. Agarwal et Al. Design principles for visual communication. in ACM (2011), 54(4), 60-69. doi: 10.1145/1924421.1924439
18. An article: 7 Tips for Evaluating Data Visualization Software. <http://data-informed.com/7-tips-for-evaluating-data-visualization-software/>
19. An Article: Difference between Symptom and Sign. <http://www.medicinenet.com/symptoms_and_signs/article.htm>
20. Jacqueline Strecker et Al. Data Visualization In Review. <http://idl-bnc.idrc.ca/dspace/bitstream/10625/49286/1/IDL-49286.pdf>
21. <https://nccih.nih.gov/health/whatiscam/chinesemed.htm>
22. <https://www.practo.com/>
23. <http://www.health.com/health/gallery/0,,20513624,00.html>
24. An Article: Urinary Tract Infection (UTI) <http://www.mayoclinic.org/diseases-conditions/urinary-tract-infection/basics/definition/con-20037892>

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