Decision Support - Dynasty Triage Advisor for Powerful Medical Decision-Support

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Dynasty Triage Advisor uses Bayesian technology from Hugin Expert to enable a powerful medical decision-support solution that is easy to use, flexible, and appropriate for patient or healthcare provider use. Using the most mathematically sound principles (uncertainty and belief networks) as well as the most up to date statistics for decision-making, this is the first automated decision-support solution that actually emulates the way the most experienced physicians make triage, diagnostic and therapeutic judgements.

Medical Decision Support Using Hugin Expert Bayesian Technology

Dynasty is the leading provider of Intelligent Application Frameworks that pragmatically embrace Artificial Intelligence techniques and technology to create mission-critical, scalable and reliable transactional application systems. Intelligent Application Frameworks build on Dynasty's patented, scalable, future-proofed technology for component development that has delivered applications into production at major global accounts since 1991.

Dynasty has forged a strategic marketing and technical partnership with Intelligent Diagnostics Inc., the leading provider of intelligent medical diagnosis software products, to introduce a ground-breaking intelligent healthcare solution: Dynasty Triage Advisor".

Dynasty Triage Advisor uses Bayesian technology from Hugin Expert to enable a powerful medical decision-support solution that is easy to use, flexible, and appropriate for patient or healthcare provider use. Using the most mathematically sound principles (uncertainty and belief networks) as well as the most up to date statistics for decision-making, this is the first automated decision-support solution that actually emulates the way the most experienced physicians make triage, diagnostic and therapeutic judgements.

Dynasty Triage Advisor is future-proofed as it has been developed using the Dynasty Development Environment and so is specified independently of the target hardware, operating system, GUI, middleware, transaction processor and database software on which the application is to be deployed.

Dynasty Triage Advisor is offered in a number of editions that address the specific requirements of medical decision-support in different contexts.

An Introduction to Triage

The term Triage means prioritizing patients based on the urgency of their situation. Proper performance of triage assures a reasonable possibility of serious disease always takes precedence over a reasonable possibility of a minor disease. Its purpose is to minimize the delay in providing service to patients.

Triage has three major steps:

- Early patient assessment this is the most important step. Due to the overwhelming load in the majority of hospital emergency rooms it should be short to keep the system flowing. On the other hand, the assessment process should be thorough enough to determine the urgency of the situation.
- Urgency determination this is the central feature of every triage system and is based on the information from the previous step.
- Proper disposition the final step is assigning the patient to a proper care area.

Implementing a Triage System

Originally triage was a task in the hospital emergency room; where a physician was responsible for the evaluation and proper disposition of patients. In due course the task was transferred to registered nurses.

Since publication of the first triage books triage systems have become far more common. Triage books contain algorithms and decision trees that provide step-by-step rules for making a correct patient disposition. These books have allowed triage to be performed by a variety of personnel with less formal training.

Triage is not only administered when patients arrive at the hospital emergency room (onsite triage) but also before arrival at the emergency room (offsite triage.)

A typical offsite triage solutions allows patients to call a telephone call center and talk to a trained operator. The operator uses one of the algorithmic triage book to provide the caller with a disposition.

More information is available to when performing triage in the emergency room. The patients look and vital signs are examples of such additional information. This information is not readily available when performing offsite triage. Offsite triage is therefore based more on subjective data than is the case for onsite triage.

Algorithmic Approaches to Triage

Triage books use a number of algorithms (typically decision trees) as the basis for non-medically trained personnel performing triage.

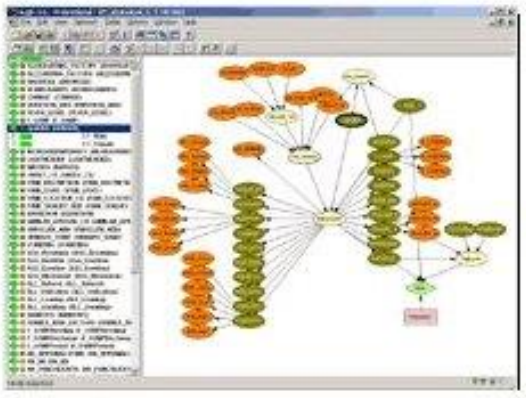
There are a number of problems with this approach:

- In medical decision making both the input data on which a decision is based, and the eventual outcome of that decision are inherently uncertain. Decision trees are unable to efficiently handle such uncertainty.
- The input to triage systems is mainly information provided directly by the patient. The patient might not be able to provide all of the requested information. Decision trees are not able to handle missing information.
- Maintaining decision trees in light of new knowledge is a difficult task. Adding and deleting rules, especially when the size of these trees is large, has very high overheads and is error prone.

Decision trees are not the only algorithmic approach that can be used for decision-making. A good alternative is the Bayesian approach based on probabilities. Probability is well understood and accepted measure of uncertainty in general, and in particular in the medical context.

The correct diagnosis of a patient presenting with a combination of symptoms is a good example of how uncertainty is inherent in the practice of medicine. Using a probabilistic approach, missing information can be handled in much the same way that other uncertainty problems are managed.

The main goal of triage is not a diagnosis, but rather the proper disposition of the patient. Because the decision is based on uncertain information a method is required to reflect the benefits and costs of the alternatives. In Bayesian systems the worth of a decision is called the Utility.



One of the DTA net's developed using the Hugin GUI - Click picture to enlarge

Medical Decision Making

Each patient has a combination of problems, one of which is the most important to the patient. This problem is called the chief complaint.

For example a patient with stomach pain, nausea and diarrhea might consider stomach pain or diarrhea as the main problem.

An experienced physician follows an iterative process to diagnose a disease from a set of problems (symptoms):

- Based on the chief complaint the physician formulates a sorted list of diagnoses based on the probability of each diagnosis given the specific circumstances for that patient.
- Then by iterative tests the physician updates this list, for example deleting a number of diagnoses and bring one or two to the top of the list. A test can be as simple as asking a question.
- Finally, based on the results of the tests, the physician has one or two diseases that are good matches for the set of presenting symptoms in the patient.

This is the correct way to make a medical diagnosis and this is the way experienced doctors perform the task.

Once a diagnosis, or more likely potential diagnoses, has been made a decision needs to be made as to what to do next. This process is inherently uncertain as it is possible that there could be more than one underlying cause that leads to the diagnosis.

Recognizing that uncertainty exists the physician can make a decision so as:

- To provide maximum coverage for all of the potential underlying causes.
- To further diagnose between the alternatives.
- To ensure that the real underlying cause is not missed.

The technical term for this process is utility-based decision-making.

Dynasty Triage Advisor"

The triage process used by Dynasty Triage Advisor is a decision tree with two parts:

- The first part is a series of questions designed to exclude immediately life-threatening conditions such as massive bleeding or Myocardial Infarction (heart attack). Also excluded at this first stage are special cases such as pregnancy or AIDS. If the user answers yes to any of these questions they are advised to seek emergency medical care immediately. No further triage is performed.
- The second step is a triage system that uses a Bayesian approach for inference, based solely on subjective data provided by the patient. The system emulates the way the most experienced physicians make triage, diagnostic and therapeutic judgments.

The Bayesian Approach to Triage

Dynasty Triage Advisor contains a list of differential diagnoses for each chief complaint. Each of these diagnosis has an initial probability; this is the probability of having that disease when the only thing we know about the patient is the chief complain. We will see shortly where the initial probability comes from.

For each of the chief complaints a series of questions are defined. Each of these questions is related to a specific symptom and are typically the same questions a physician will ask when encountering the same situation.

As questions are answered new information is available which causes the probability table for the different diagnoses to be updated. This table is then resorted so the most likely diagnosis will float to the top of the table.

Differential Diagnosis List

The differential diagnosis list includes the most common diseases within the context of each chief complaint. Hundreds of diseases could cause a specific complaint. In selecting the list of chief complaints tom include in Dynasty Triage Advisor the following assumptions were made:

- The list includes the most commonly encountered diagnoses in each community (for example North America, Japan, Italy.) As the solution is made available in other geographies the list may need to be extended to reflect specific local conditions.
- The list also includes life-threatening diagnoses, even though they are not necessarily common.
- Diagnoses that have similar presentation on the basis of subjective information are grouped together. For example Peptic Ulcer and Gastritis are grouped together as they can look similar.

The probability associated with each diagnosis comes from standard medical textbooks. The probabilities are usually dependent on demographic information relating to the patient.

For example, the probability of ovarian torsion is zero for males.

The probability of certain diseases is known to increase with age so the approximate age of the patient is also important input to the diagnosis process.

It is important to understand that Dynasty Triage Advisor has been trained (as are real physicians) to recognize common diseases that present in common ways. A patient that presents with a very uncommon diagnosis will possibly be incorrectly disposed by the system.

The extent to which the patients' answers are consistent with the underlying diagnosis model of Dynasty Triage Advisor can be checked at runtime. This allows a degree of validation of answers so that the risk of non-notified misdiagnosis is reduced.

Questions

Each question asked by Dynasty Triage Advisor is related to one specific symptom.

There are usually a number of common questions that are general to the chief complaint regardless of the diagnosis. Examples of these questions are the location and severity of pain.

Another group of questions are specific to a certain group of diagnoses, or possibly even to one specific diagnosis.

The order in which questions are asked is designed so that the common questions are usually asked early in the triage session. More specific questions are asked later in the session.

Each question represents a symptom. Each of these symptom has an assigned probability in the context of each potential diagnosis. These probabilities come from the medical literature.

Some changes to the probabilities can be required to reflect specific circumstances in certain geographies. For example in tropical climates certain diagnosis can have a higher probability that in cooler climates.

The medical literature rarely reports the required probabilities directly. Usually they are reported in qualitative form (as adjectives) rather than quantitative (as numbers).

Creating the rules used by Dynasty Triage Advisor involves translating from qualitative to quantitative form. Expert clinicians are then consulted to possibly adjust the probability numbers based on their real-world experience.

Currently the quantitative numbers used by Dynasty Triage Advisor reflect relatively typical presentations of a disease. If a patient presents with an atypical presentation then Dynasty Triage Advisor could misdiagnose - as would the vast majority of physicians.

Disposition

Dynasty Triage Advisor uses two different methods for disposition:

- The dispositions are fixed for the life-threatening and special conditions that the patient is asked about before the triage session starts.
- Within the main Bayesian part of the system dispositions for conditions uses a utility based approach. This allows the system to make the best decision in an uncertain situation.

Utility-Based Disposition

The best way of understanding the concept of utility within the context of triage is through loss functions.

A loss function is defined for each decision and each of the differential diagnosis. The function represents the loss incurred when a specific decision is made conditional on a specific diagnosis being the true differential diagnosis. The loss function is unit-less (sometimes the units are referred to as utiles).

The loss function used by Dynasty Triage Advisor is a combination of costs, risk to human life because of the lack of treatment, risks by over treating, etc.

For example:

- If a patient suffering from heartburn is told to go to the emergency room, it creates unnecessary travel and inconvenience for the patient, a monetary cost to the emergency room treating the patient, and resources used by the emergency room may have been used to treat others.
- A patient suffering a myocardial infarction (heart attack) is told to stay home and see if the symptoms get worse, may suffer irreversible damage, including possible death.

In both of these examples the decisions would be classified as wrong, but one is clearly more wrong than the other.

The loss function must synthesize all of the various factors to form real-valued quantities that can be numerically compared.

The loss function in this example can be quite difficult to quantify, but represents a necessary step in any decision analysis.

Core Assumptions

Dynasty Triage Advisor is based on the following core assumptions:

- The main purpose of this system is reliable disposition; diagnosis is offered for information purposes only. Diagnosis is beyond the scope of conventional triage as it requires objective information such as blood tests, MRI tests etc.
- Decision making is based on a single fault model. This means that it is assumed that all of the patients presenting symptoms have only one explanation. For example, the patient has either a heart failure or pneumonia. This a simplification as in reality this patient could have a pneumonia overriding a chronic heart failure.
- The complaint is the result of a recently onset problem.
- The patient is a relatively healthy individual. This is taken into account on the initial screening questions.
- The system is primarily designed for lay users and is not designed to assist physicians in difficult cases such as uncommon diagnoses or atypical presentations. Having said that, the system has also been designed on the basis that nurses will benefit from using the system in the day-to-day practice of triage.

Go to Dynasty website www.dynasty.com for more information and to download DTA flyer and white paper.