Dodes (diagnostic nodes) for Guideline Manipulation

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ABSTRACT

Background: Treatment recommendations (guidelines) are commonly represented in text form. Based on parameters (questions) recommendations are defined (answers). Objectives: To improve handling, alternative forms of representation are required. Methods: The concept of Dodes (diagnostic nodes) has been developed. Dodes contain answers and questions. Dodes are based on linked nodes and additionally contain descriptive information and recommendations. Dodes are organized hierarchically into Dode trees. Dode categories must be defined to prevent redundancy. Results: A centralized and neutral Dode database can provide standardization, which is a requirement for the comparison of recommendations. Centralized administration of Dode categories can provide information about diagnostic criteria (Dode categories) underutilized in existing recommendations (Dode trees). Conclusions: Representing clinical recommendations in Dode trees improves their manageability, handling and updateability.

Keywords: dodes, ontology, semantic web, guidelines, recommendations, linked nodes
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1. INTRODUCTION

Treatment guidelines for cancer entities are often represented in written text or simple diagram form[1,2]. These guidelines contain mainly recommendations based on relevant literature. Albeit common guidelines exist, individual departments tend to have their own internal treatment recommendations, based on the parameters of patients and their disease [3,4].

Guidelines, written in plain text have several negative properties:

Complexity: For a specific treatment to be defined various parameters need to be obtained. Treatment options within a single disease entity are also manifold with several parameters, which need to be defined before treatment is initiated. In such a setup many different combinations can arise and lead to different compositions and timing, resulting in a number of different treatment reccomendations. This sheer complexity makes it even more difficult to overlook recommendations when written in plain text.

Updates: Evidence based medicine is not static and to remain useful, existing guidelines need to adapt to new information, treatment recommendations based on new knowledge have to be incorporated.. To maintain and update documents in text form in a concise and consistent way needs a lot of effort and is quite inefficient [5].

Comparison: In the current state, it is very difficult to compare different treatment strategies applied by different departments. It is worthwhile to stress, that comparisons of different treatment guidelines is of great importance. With plain text guidelines it is very difficult to detect relevant and important differences in treatment strategies applied in different departments. Comparison can also be used to compare different versions of recommendations or classifications [6]

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The fore mentioned properties have grave consequences. We hypothesize, that relevant information and potential new knowledge cannot be inferred in an efficient and concise manner. Moreover, the time to maintain recommendations and treatment strategies is considerably high. Due to these problems guidelines are often poorly structured and sporadically updated.

Due to the widely used TNM staging system [7-9], information that is used in oncology / radiation oncology is very suitable for catalogization. Due to the biological properties of tumor cells and the effect of radiation a treatment needs to be planned completely in advance and is only seldom altered during its course. Therefore there is a clear structure in workflow consisting of diagnostic procedures (parameter gathering), treatment decision (defining the parameters of treatment) and subsequently the treatment application. Having all required paramteres before decision making makes radiation oncology very suitable for ontology systems.

To overcome the mentioned problems we propose a system, based on decision trees implemented as domain specific ontologies.

2. METHOD

To find a treatment recommendation one must search based on individual parameters. This may be generally represented by questions and corresponding answers.

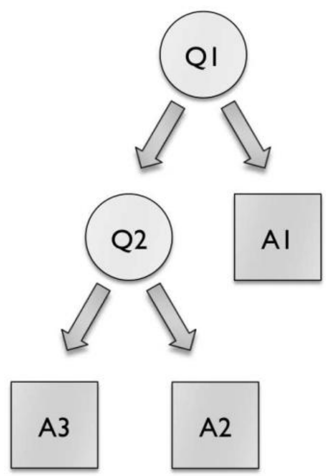

Figure 1. Recommendations represented as questions and answers

For the concept of categorizing therapeutic options the "Dode" is being introduced. The Dode (Diagnostic Node) contains basic features of a linked node, a concept, which is well known in programming languages. In addition to the linking characteristic these Dodes contain treatment recommendation information. A Dode is a unit, which represents the Question aspect in its description and the Answer in the recommendation.

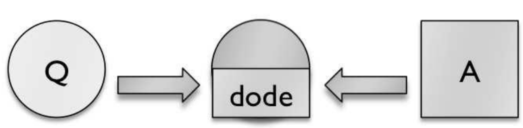

Figure 2. A Dode (Diagnostic Node) contains elements of questions and answers.

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Dodes are arranged in the form of a tree consisting of a starting Dode with sub-Dodes, each recursively containing a variable amount (0-n) of their own sub-Dodes. All paths down from the starting-Dode end in terminal-Dodes that do not contain further sub-Dodes.

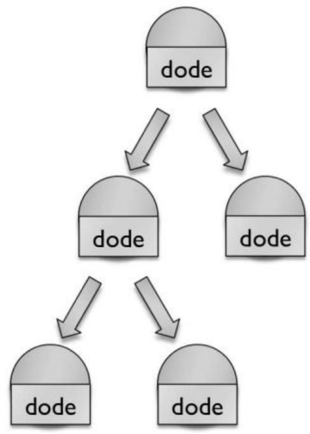

Figure 3. Linked Dodes forming a Dode tree

Treatment recommendations, as they are contained in Dodes, are passed down the diagnostic tree hierarchically. The treatment recommendation of any Dode of a tree is valid for all sub-Dodes. In the process of specifying parameters in the search of a therapeutic recommendation, the therapeutic information is collected on the way down the Dode tree. As a terminal Dode is reached, the collected treatment recommendations represent the treatment recommendations based on the diagnostic parameters.

3. RESULTS

The Dode provides a reasonable unit for representation of recommendations based on diagnostic parameters. To prevent redundancy, Dodes need to be classified into Dode categories. Each Dode category represents a diagnostic parameter. Each Dode must provide a clear representation of a single diagnostic parameter (value). A further condition is that on the way from the starting Dode to the terminal Dodes, each Dode category must be encountered only once. The Dode tree structure provides high flexibility and maintainability. When a Dode category is to be removed a default sub-tree may be chosen, otherwise a new sub-tree which is valid without the lost Dode category must be defined.

A new Dode category may be added to the Dode tree as long as the abovementioned conditions are met. In case there is a Dode within this new category, which corresponds to the old default root, the sub-tree from the point of insertion can be linked to this new Dode.

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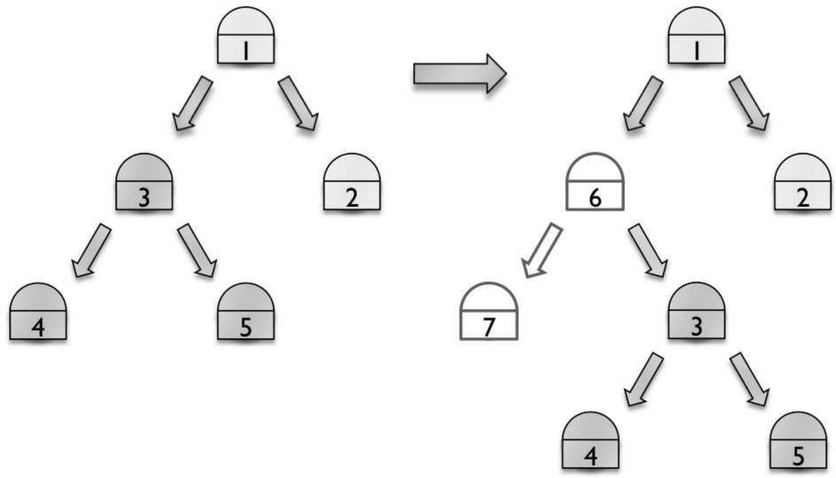

Figure 4. Inserting a new Dode into an existing Dode tree.

To demonstrate an specific Dode tree we present a sample recommendations tree for primary radiotherapy and antiandrogen therapy in prostate cancer based on T Stage, PSA value and Gleason Score[1,2]. The value ranges used can be read directly from the Dodes.

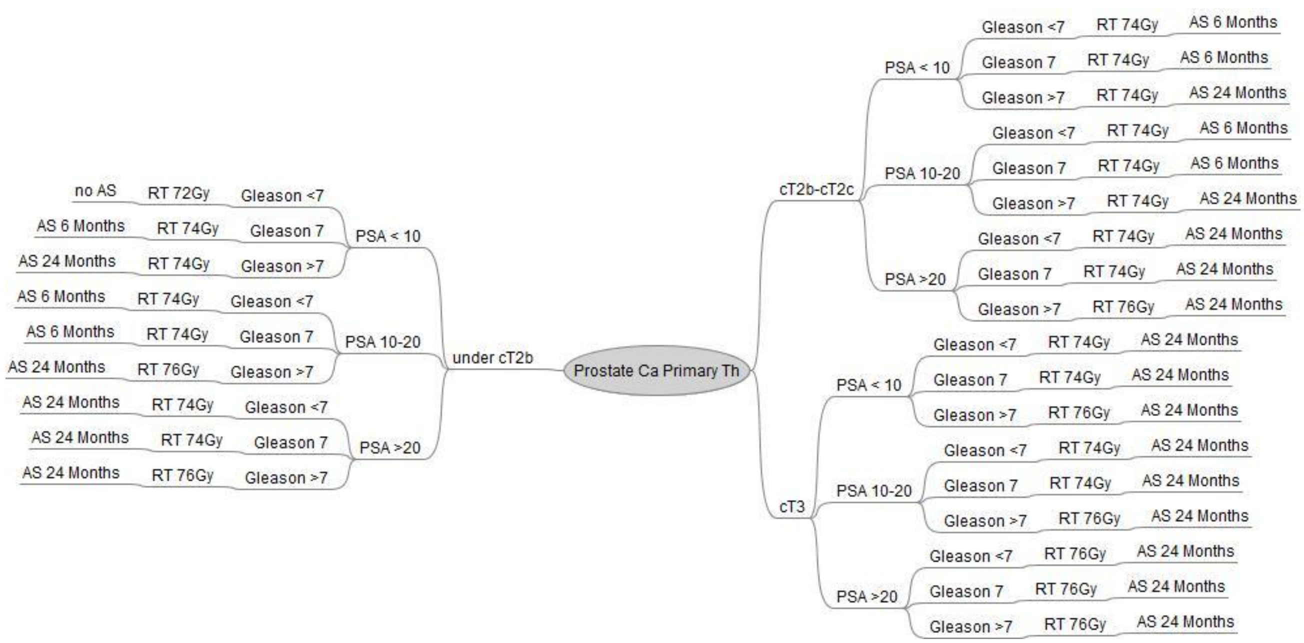

Figure 5. Primary radiotherapy and hormone therapy for prostate cancer represented as a Dode tree (based on T Stage, PSA value and Gleason Score)

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4. DISCUSSION

For a certain group, such as a single department, treatment recommendations may be represented with a Dode tree. The Dode tree provides clear recommendations for specific combinations of parameters. The ordering of the Dode categories is irrelevant. As with normal recommendations, they are not able to cover the soft factors that are involved in decision-making, they can however provide a clear representation of recommendations based on predefined criteria. The advantage of having recommendations in Dode tree format is being able to compare different Dode trees. Standardized Dode Categories and their contained Dodes (ranges, values) need to be agreed on. Once these are defined it is possible to automatically go through two different trees from the starting Dode to a terminal Dode with all combinations of parameters (encountering each Dode category not more than once). If two trees are passed with the same parameters, the recommendations collected at the terminal dode can be compared. In case the recommendations are different, the path can be traced back to see in which Dode category the deviation originated. It is possible that Dode categories of one tree are not represented in another Dode tree.

The practical implication of these results is that different groups can identify the source of deviating recommendations for identical diagnostic parameters. Through this method, groups may also be informed of diagnostic categories that they have not been implementing in their decision-finding process. Practically, these differences may lead to a very clear and focused discussion and re-evaluation of recommendations. Furthermore, a group may be informed of a new parameter (laboratory result, histological parameter, scoring system) and its potential unrecognized relevance. The next step in implementation is to provide a neutral ground for a standardized and centralized collection of Dode categories and their containing Dodes. With access to this collection, different groups may compose their own Dode trees, adding new Dode categories to the database if required. With set parameters, the database could find the median recommendation, which could then also be used for comparison to the recommendations of individual groups.

As new Dodes are added to the database, existing users could be informed of new Dode categories, leaving them to decide whether these should be implemented. In case of matching sub-trees these could be partially automatically integrated from the median recommendations or the adding institution’s sub-trees.

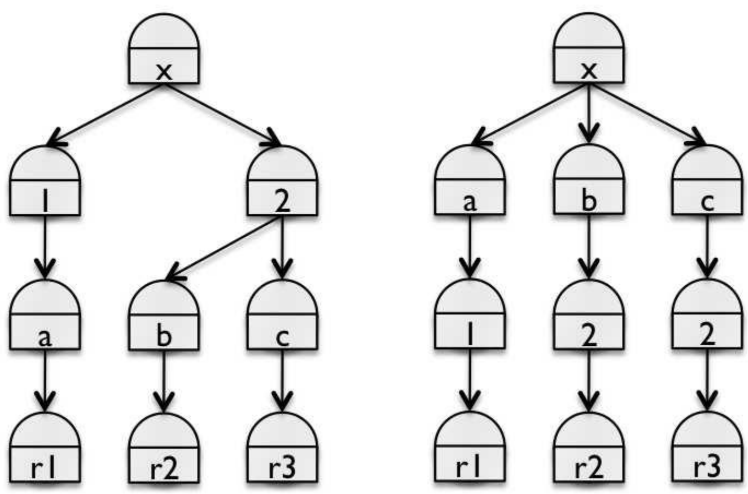

Figure 5. different implementation of the identical Dode categories and recommendations

The image above shows two trees using standardized Dodes: X, A, B, C (category I), 1 and 2 (category II). From these the recommendations are represented by R1, R2 and R3. If R3 is selected as an example, the algorithm can identify the Dodes from the first tree leading to R3, these are X, 2 and C. These are then used to find the appropriate recommendation within the second tree.

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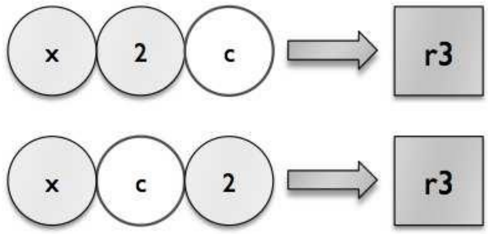

Figure 6. the ordering of Dode categories is irrelevant for the recommendations

Dode trees are represented in a normalized from. This enables comparison of different Dode trees and the measurement of the deviation from the 'most common' tree. Furthermore it allows a straight forward representation as a ontology, which will be useful for real applications [10,11]. The normalization consists of a static Dode (node) sequence and a transitive reduction [12] to remove redundancies

A simple example of the transitive reduction principle is outlined in Fig. 7

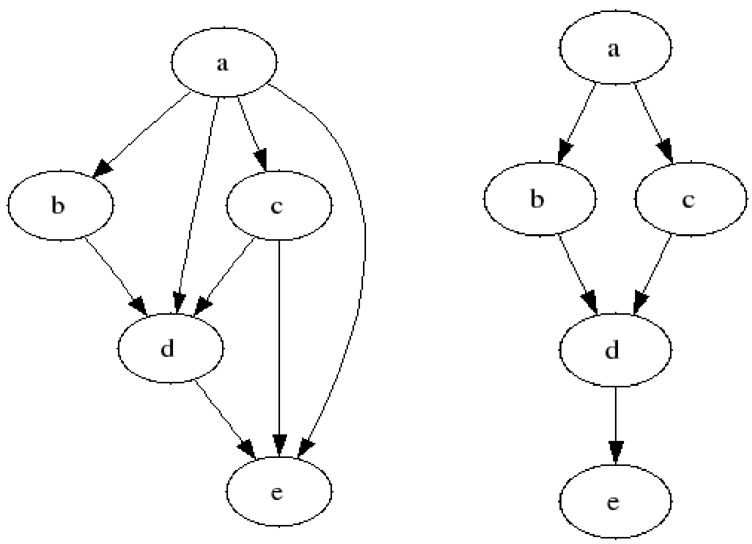

Figure 7. Transitive reduction. Left: Tree before transitive reduction. Right: Tree after transitive reduction.

Transitive reduction [12] preserves the reachability of a node in a graph and does not affect the inherited attributes. The pairwise comparison between Dode trees is twofold: a) structure level and b) property level (recommendations). The structural comparison is done using tree edit distance. Tree edit distance is a common similarity measure between different rooted, ordered trees. It measures the minimum cost of transforming one tree into the other by a sequence of elementary operations. The concept was introduced by Tai [13]. We use this distance to compare Dode trees on the structural level and to calculate the mean Dode tree (the most common tree in the system):

$$T_i^D = \frac{\sum_j T_{ij}^D}{N}.$$

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Where T_{ji}^{D} is the tree edit distance between a tree i and a tree j. N is the total number of trees in the system. Then T_{i}^{D} measures the mean distance from a tree i to all other trees in the system. The tree with the smallest mean distance is the most common tree in the system – the mean Dode tree. Each mean Dode tree can now be compared to this most common tree, revealing structural deviations.

For the comparison on the property level we pairwise compare leaf by leaf (recommendations) on different Dode trees we use a simple matching counter:

$$D_{ij} = \sum_{k}^{N} \delta(D_{ik}, D_{kj})$$.

With $0 \leq D_{ij} \leq N$. N is the number of properties and D_{ij} is the pairwise distance on the property level between two Dode trees. $\delta(a,b)$ is the Kronecker Symbol. D_{ij} counts the number of matching properties of Dode tree i and Dode tree j.

5. CONCLUSION

Diagnostic Node (Dode) trees represent a reasonable method for representing treatment recommendations. The Dode tree provides good updatability and flexibility. With standardized Dode categories, clear comparability of treatment recommendations provides a sound basis for identifying causes of deviating recommendations. A centralized neutral database can provide an automated means of presenting new Dode categories as well as a comparison of a group's recommendations with the median.

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