Paper PP20

Understanding the Power of Information Modeling for Efficient and Effective Visualization

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ABSTRACT

Clinical trial data - stored as a network - can be evaluated from any perspective (for instance, by patient, clinical site or geographical perspective). This is achieved by utilizing an ontology-driven information model, that is flexible and scalable, coupled with a platform built on a property graph database where data, belonging to an individual event, process or entity, is stored in individual information units that are coined a 'Holon'. In addition, relationships that exist between these Holons are stored and utilized for efficient data exploration.
This presentation will draw on the experiences encountered implementing a visualization application in Reflect, a modern software product for the configuration of tailored applications aimed at data exploration and data visualization, for a Swedish Quality Registry (CPUP) containing data for more than 5000 patients using data curated and integrated utilizing an ontology built on concepts identified across a broad range of medical specialties and experts in the field.

INTRODUCTION

Life science and health care continue to struggle with complex and time-consuming processes to make data available, understandable and useful. Now new technology can be used to work with data not stored in rigid tables but as many-sided medical messages.

Data, a huge number of variables from different sources, often makes it cumbersome for the end user to understand. Reflect is a new tool that is flexible, scalable and fast with a web based, interactive and configurable user interface. This tool will give the end user broader search possibilities and a more flexible way to work. Reflect will be a powerful data exploration tool where the user can share findings with colleagues in the same application or work with different parts of the same dataset in different applications.

The purpose with this poster is to demonstrate a new approach of modeling and indexing data for effective and efficient exploration of life science and health care data.

INFORMATION MODELING

Reflect utilizes an information model built as a graph, that keeps information together in related small entities, called Capish Holons, supplemented with an Ontology holding the rules of the information model. These blocks, together with a new technique for indexing data, results in both faster and broader search possibilities.

CAPISH HOLON

The Capish Holons collect data corresponding to a common concept and are more detailed than relational database tables as metadata also is included. The Capish Holon can be defined as the minimum information package that a person knowledgeable within the domain, can understand and use for making a decision. These Capish Holons should be large enough to include a number of individual data points, but small enough to be combined as "Lego pieces" into a complete description of, for example, a specific patient. This limits the complexity. The message itself is structured into fields, values and attributes.

ONTOLOGY

The Capish Ontology is designed to describe the structure of the content, rather than trying to explain the content. Also, the Capish Ontology covers any knowledge domain and is an objective way of describing the real world. The information is modelled in such a way that both a human and a computer system can take full advantage of the information being represented.

To fulfill this, the granularity of the graph should correspond to information chunks of a size that is easy to interpret and understand. In addition to this, there shall be a possibility to combine data that makes most sense when viewed together, e.g. groups, panels, views, dashboards etc.

The Ontology sets the rules for the Information Model and describes the definitions of all the entities in it, e.g. how the Holons relate to each other, which fields are included in each Holon, datatype of the fields, units to be used.

NEW TECHNOLOGY

INDEX STRUCTURES

Capish's information model is built as a graph containing related Holons, and this new approach allows for the creation of several indices [1]. The indices represent:

- ✓ individual Holons (identity index)
- ✓ Holon types (Holon type identity index)
- ✓ existence of indirect relationships (relation index)
- ✓ property values (property index)

In particular the relation index provides a new concept and can be used to efficiently search using indirect relationships or search for specific criteria (via property indices) and retrieve a broader result set. The implementation of the relation index in conjunction with the other indices therefore allows to answer complex questions such as:

a) Find all blood pressure measurement that are considered high and that are connected to patients that were given a dose of the drug A.
b) What adverse events have been reported for patients with elevated liver values (and who received drug A)

Below are some examples that show the effect of using the indices in a search.

DESCRIPTION OF REFLECTION

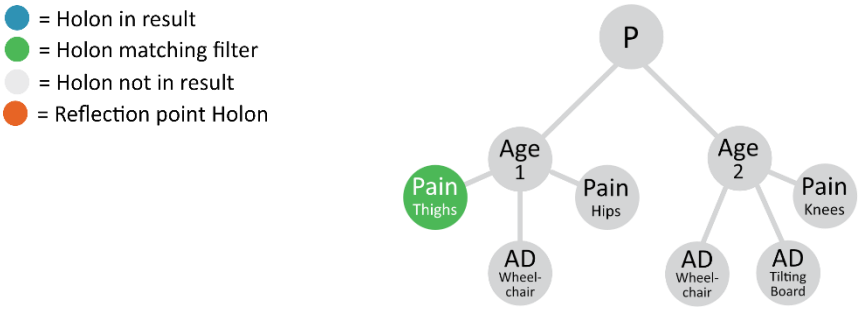

***Figure 1**: The filter is set on the Holon Pain value Thighs*

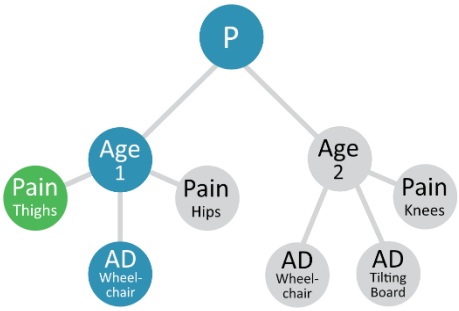

***Figure 2**: No Reflection*

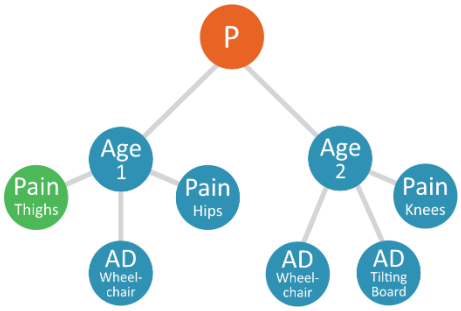

***Figure 3**: Reflection*

In the examples above one patient is selected to illustrate the effect of different approaches. A filter is set on Pain, Figure 1, and the other figures show the result sets for two different approaches that answer on different questions. The first example, Figure 2, answers the question “What Assistive Devices are used when a patient has pain in his thighs?”. The result set shows data related to the time the pain occurred (Assistive Devices used during the time the patient had pain in his thighs (Age 1)).

The second example, Figure 3, answers the question “What assistive devices and pain locations are connected to a patient with pain in his thighs?". The result set shows all events related to the patient. This approach enables searching in the database in an easier, more flexible and responsive manner that give the user a broader result set. This example operates on both direct and indirect relationships in the datasets.

In the second example, Figure 3, patient is used as reflection point which means that data is shown from a patient perspective. All data connected to a patient, directly or indirectly, will then be captured. Other reflection points e.g. the study or the site can also be of interest in an analysis of a clinical study. This possibility to change reflection point adds flexibility and value to the data set.

EFFECTIVE AND EFFICIENT VISUALIZATION

Being able to answer questions raised from different perspectives in the same solution, with the same data structure, increases the ability to explore the data in a wider context. Depending on the question at hand, either way of presenting data is valuable. Reflect is a tool that can utilize the both ways which gives the end user extended possibilities. It can be exploration of safety signals, drill-downs from aggregated data to patient profile and vice versa, free-text search, creation of subgroups and sharing filter with others.

Below the figures illustrate how reflection behaves in a visualization tool, Reflect, that uses the technology shown above and the type of question it can answer.

NO REFLECTION

The solution returns the answers to the question "What assistive devices are used when the patient had pain in his thighs?".

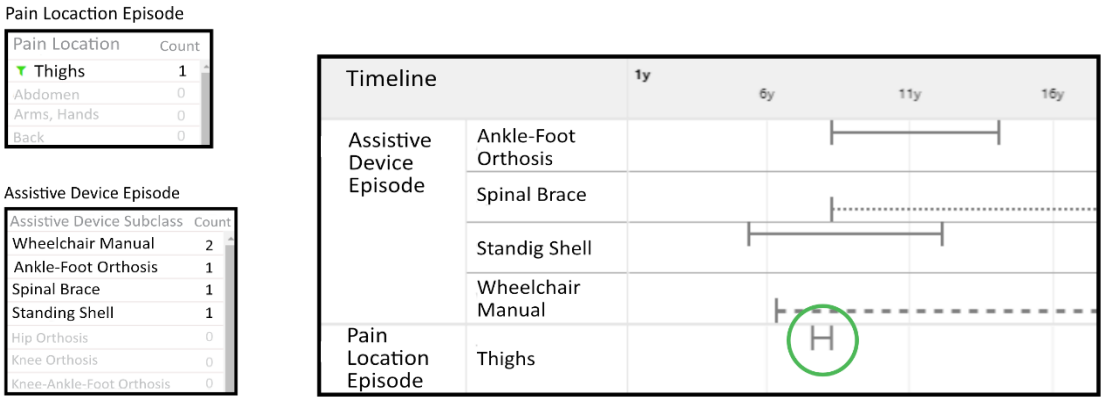

***Figure 4**: Without reflection the answer of the question shows events that occurred at the time the patient had pain. The timelines show events as episodes to describe the existence of pain between two dates.*

REFLECTION

The solution returns the answers to the question "What assistive devices and pain locations are connected to a patient with pain in his thighs?".

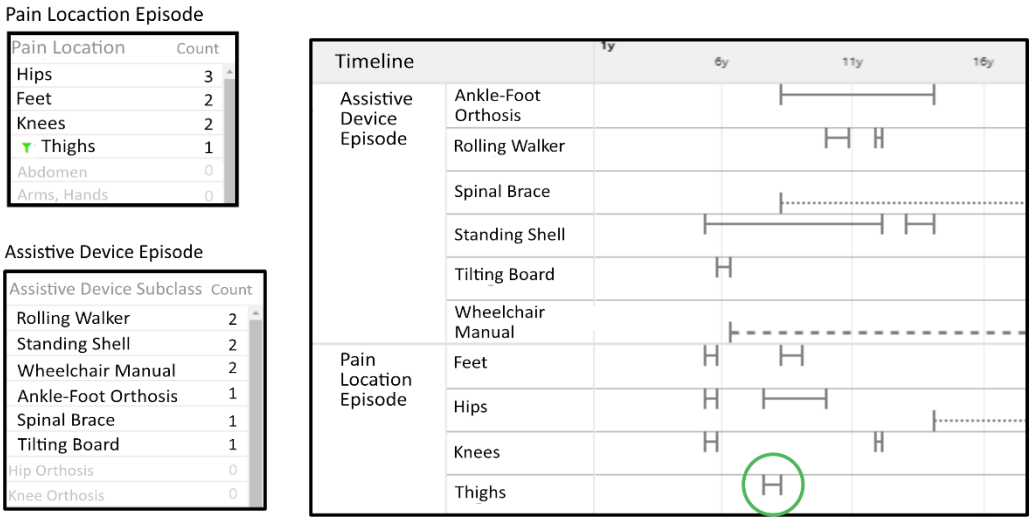

***Figure 5:** With reflection the answer of the question finds all events that ever had occurred independent of the time for the patient.*

DETAILS AND MEDICAL RECORDS

With reflection it is possible to drill-down from aggregated view to patient details to explore everything related to the patient without engaging experts doing any additional work. The other way around, from patient to aggregated information, is also possible. Another consequence of the reflection is that the full details of any patient with pain in thighs is available to be explored. A list of these patients makes it easy to jump between patients but also change to the aggregated view and look at the patient related to the whole population or in a limited cohort.

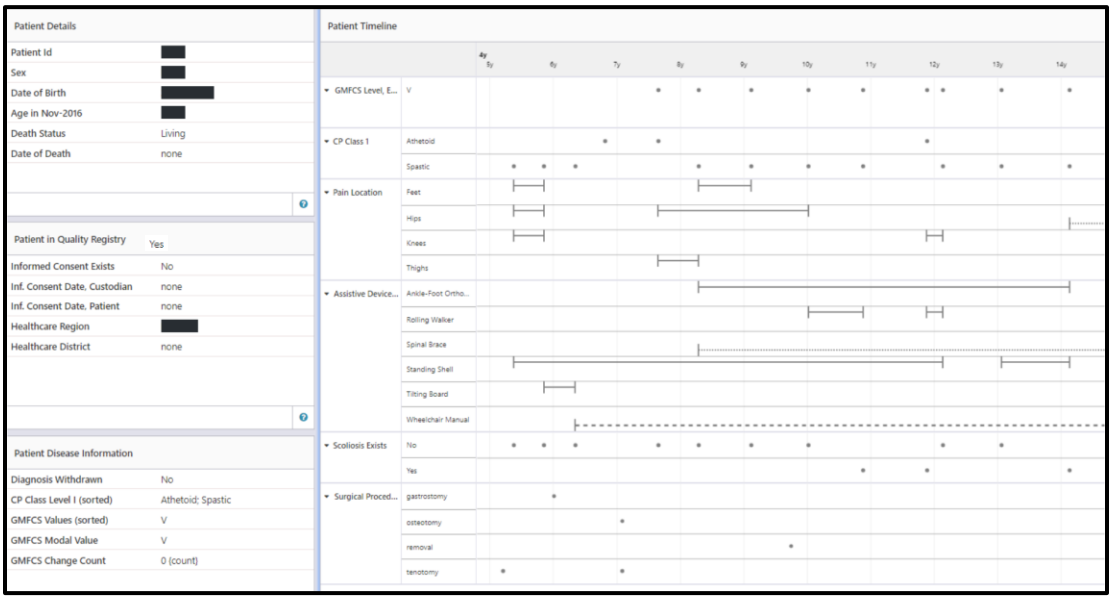

***Figure 6**: The Details view above shows a configured summary of data for a patient.*

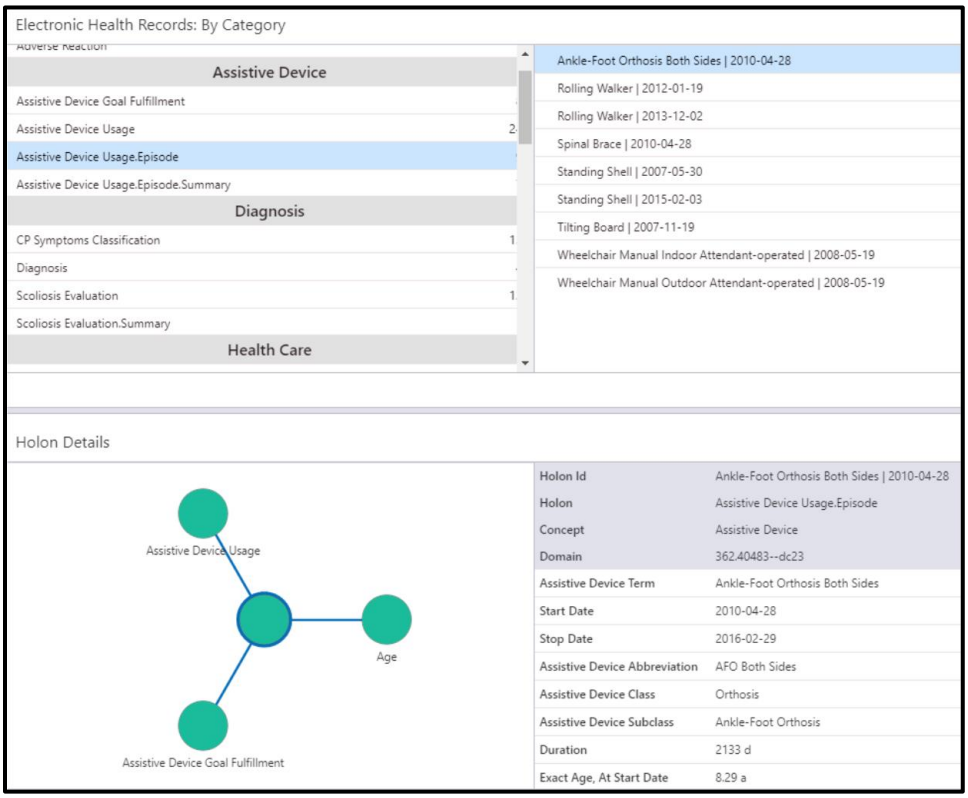

***Figure 7**: The Medical Record that contains all information from the dataset, that is added to the information model, allows to browse the data by patient, category or time.*

CONCLUSION

Developing a new ontology-based information model creates new possibilities to explore and visualize data. A model constituted of Holons, linked together with relations, directly or indirectly as a graph, can together with an advanced index structure enable end users to answer complex questions and retrieve a broader result set.

Reflect is a tool that can show both reflected and unreflected data at the same time and thereby gives the end user extended possibilities e.g. exploring safety signals, drill-down from aggregated data to a patient profile and vice versa, free-text search, creation and exploration of subgroups and sharing findings with others.

REFERENCES

1. Patent US20130246438 – Reflective logic unlocks knowledge in datasets, Staffan Gestrelius and Henrik Drews

ACKNOWLEDGMENTS

We would like to thank Gunnar Hägglund and Ann Alriksson-Schmidt at Skåne University Hospital for the collaboration, giving us the experiences of working with Quality Registries and especially CPUP (Cerebral Palsy Follow-Up Program).

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