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Explorative data analysis for process optimization in the radiology department of the University Hospital Basel

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Master thesis, Master of Sciences in Life Sciences, Therapeutic Technologies

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INTRODUCTION

The department of radiology (RD) of the University Hospital Basel in Switzerland collects time-stamped data like admission day, length of stay (LOS), intervention day (scan day) as well as scan modality and other patient associated demographic parameters. Medical imaging is considered as one of the most important biomarkers: It determines diagnosis, treatment and predicts the outcome of patients. Furthermore the diagnosis enables to prevent prolonged LOS and to improve clinical care and efficiency. An interactive visualization of the data helps the analysts to validate their experiences and generate new insight.

CONCEPT

The hospital manages about 35'000 visits annually. More than one third needs at least one diagnostic by the RD. Overall about 27'000 visits at the RD with over 75'000 scan interventions are found in 2014 and 2015. This master thesis enables the preparation and import of different data sources into one database and provides a single interface for the application. More precisely, a new developed application offers mainly three views with sorting and filtering functions.

- The *Attribute-View*: gives an overview of the attributes of the visits showing small embedded charts.
- The *Chronological-Scan-View*: visualizes the visits and its scans during a stay to identify patterns related to order, time and scan modality.
- The *Distribution-View*: clusters cases into groups in order to compare their distributions and median values.

Attribute-View (Figure 1) is the entry point for the analysis and displays attributes of all visits (cases) treated in RD in a table. Each row represents a case. The table is sortable by columns. Four small embedded graphics (a-d) in the table help to interpret numbers and give a quick overview of the data. The intension of this view is to give an overview of the data, to identify *DRG outliers* and at the same time allow to focus on detail information.

Case ID	Patient ID	MDC	MDC Description	DRG	DRGs Cases LOS	Entry Date	LOS	ALOS	Difference (LOS-ALOS)	Scan Modalities	DRG Description
84883531	3443401	1	Nervensystems	B02C		13.06.2013	8	14.2			Komplexe Kraniotomie ...
84897348	3243224	1	Nervensystems	B02C		22.06.2013	21	14.2			Komplexe Kraniotomie ...
84894162	3269085	1	Nervensystems	B02C		27.06.2013	17	14.2			Komplexe Kraniotomie ...
84905437	3447139	1	Nervensystems	B02C		04.07.2013	8	14.2			Komplexe Kraniotomie ...
84908511	3274684	1	Nervensystems	B02C		10.07.2013	6	14.2			Komplexe Kraniotomie ...
84920255	2143525	1	Nervensystems	B02C		19.07.2013	34	14.2			Komplexe Kraniotomie ...
84930390	3424992	1	Nervensystems	B02C		02.08.2013	25	14.2			Komplexe Kraniotomie ...
84937791	3447779	1	Nervensystems	B02C		12.08.2013	8	14.2			Komplexe Kraniotomie ...
84946551	3364982	1	Nervensystems	B02C		21.08.2013	8	14.2			Komplexe Kraniotomie ...
84899290	3341547	1	Nervensystems	B02C		25.08.2013	12	14.2			Komplexe Kraniotomie ...
84948518	3451412	1	Nervensystems	B02C		28.08.2013	13	14.2			Komplexe Kraniotomie ...
84961902	2387654	1	Nervensystems	B02C		08.09.2013	37	14.2			Komplexe Kraniotomie ...
84980943	2131888	1	Nervensystems	B02C		01.10.2013	11	14.2			Komplexe Kraniotomie ...
84991529	3351829	1	Nervensystems	B02C		11.10.2013	32	14.2			Komplexe Kraniotomie ...
84999295	3437187	1	Nervensystems	B02C		21.10.2013	45	14.2			Komplexe Kraniotomie ...
84999696	2085081	1	Nervensystems	B02C		30.10.2013	9	14.2			Komplexe Kraniotomie ...

(a) (b) (c) (d)

Fig. 1: ***Attribute-View***
The graphic shows 16 cases from DRG B02C. Seven out of these cases are prolonged because the LOS is longer than ALOS. Four of them are defined as *DRG outlier*. This is visible because they exceed the gray *inlier* range. All other visible cases are *DRG inliers*.
(a) A chart shows sorted length of stay (LOS) of the same DRG, the current case is marked red.
(b) A horizontal bar represents the LOS of the case.
(c) A horizontal bar shows the difference between LOS and the average length of stay (ALOS). A green bar indicates a LOS smaller than ALOS. A red bar indicates a higher LOS. The gray bar in the middle represents the *inlier* range of the DRG.
(d) Each scan during the stay builds a bar with a specific color for a modality (e.g. green for CT)

The ***Chronological-Scan-View*** gives an overview about scan interventions during a stay. Crucial is the time point of the scans as well as the scan modalities. To illustrate the variances among the time between the scans three DRG examples are displayed in Figure 2.

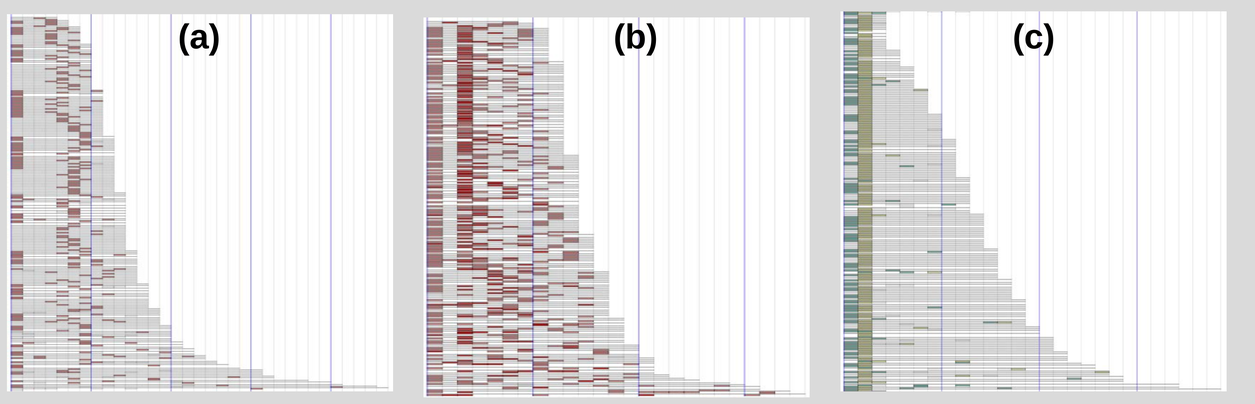

Fig. 2: ***Chronological-Scan-View***
Visits are displayed as lines. The modalities of the scans (rectangles) during the stay are colored: yellow for magnetic resonance imaging (MRI), green for computed tomography (CT) and red for conventional radiography (CR). The width of the scan is one day. Stacked rectangles indicate several scans on the same day. Blue guide lines demonstrate week duration. The left graphic (a) shows CRs for 210 (I09C) cases. The middle graphic (b) shows CRs for (F06E) cases. The right graphic (c) shows (B70D) cases which mainly have the first CT on admission day and the first MRI on second day.

The ***Distribution-View*** (Figure 3, red marked) shows the frequency distributions of cases grouped into admission day. The calculated value is the difference between LOS and ALOS. Each weekday is displayed in a separate frequency distribution. Additionally the median value of each distribution with its confidence interval (95%) is displayed.

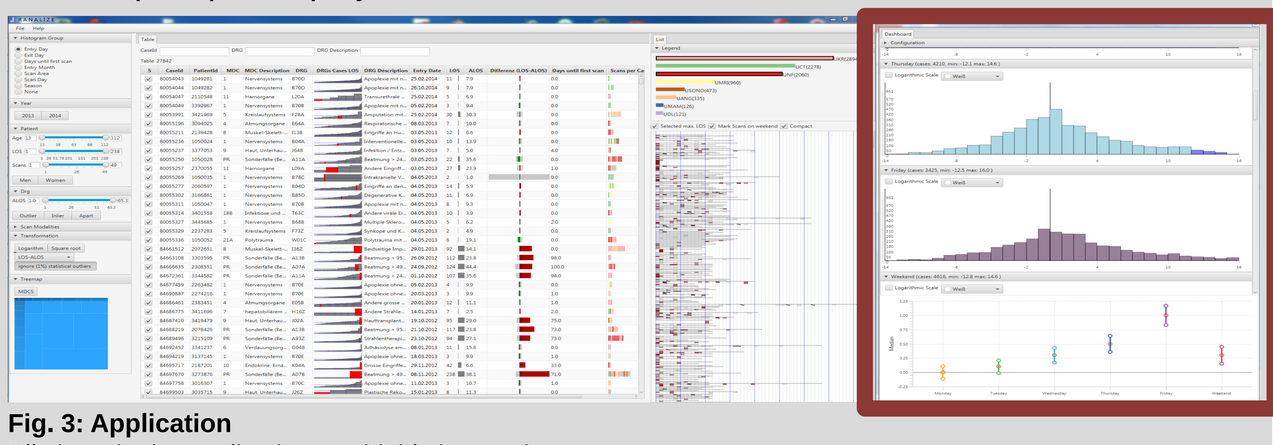

Fig. 3: Application
All views in the application are highly interactive.

RESULTS

In average, one visit including radiology intervention records 2.5 scans. The *Attribute-View* and the *Chronological-Scan-View* compare detail information of the visits and highlight outliers without losing the context. The two views demonstrate the large variance of the data. All the more the filter functions are important to explore subgroup of visits interactively. The views identify process patterns of scans over time for specific disease groups. The new findings answers some hypotheses of the analysts for improving the process in the RD.

Together with statistic tools and the *Distribution-View* an inhomogeneous distribution of the admitted visits during the week was detected ($p<0.01$) with a higher registration at the beginning of the week. Also a significant higher LOS was shown for visits admitting on Friday ($p<0.05$). Additionally the first scan was conducted in most cases (58%) on admission day. A conduction of the first scan on the third residence day increased LOS significantly ($p<0.05$) compared to the conduction of the first scan on the second day.

CONCLUSION

The new developed application enables to explore visualized data and gives a tool to analyze with interactive functions. This visualization provides broader view of the collected time-stamped data with the possibility to focus on specific groups. This supports developing new hypotheses. The implemented architecture of the application allows adding new functionalities to follow new hypotheses.

REFERENCES

[1] Brodbeck, Dominique, Markus Degen, and Andreas Walter. «Supporting Strategic Planning with Interative Visualization-A Case Study of Pateint Flow through a Large Hospital.» HEALTHINF. 2013.

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