Document creation in clinical information systems

- **Document**: "discrete electronic composition about an identified patient to be read or used by a human"

- Examples: radiology report, hospital discharge letter

- Important means of communication between healthcare professionals → Swiss EPD

- Project at Erlangen: simple but practical tool for document generation
Automatic creation of documents in EHRs

- Manual creation laborious and time-consuming

- EHRs: template-based generation tools

- Basic functions: placeholder substitution, simple formatting

Patient `{patname}`, geboren am `{birthdate}`, wurde am `{admission}` aufgenommen…

Patient Max Müller, geboren am 20.8.1963, wurde am 1.3.2019 aufgenommen…

- Advanced functions often missing: conditions, filters, calculations, aggregations, advanced formatting …
Completing templates with EMR data (BGA)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
<th>Value 5</th>
<th>Value 6</th>
<th>Value 7</th>
<th>Value 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>pCO2 (M) mmHg</td>
<td>85.3</td>
<td>74.4</td>
<td>71.8</td>
<td>75.1</td>
<td>90.8</td>
<td>79.3</td>
<td>76.1</td>
<td>65.3</td>
</tr>
<tr>
<td>pO2 (M) mmHg</td>
<td>53.1</td>
<td>83.8</td>
<td>47.9</td>
<td>104</td>
<td>94.1</td>
<td>94.6</td>
<td>46.9</td>
<td>117</td>
</tr>
<tr>
<td>Hb g/dL</td>
<td>12.2</td>
<td>9.2</td>
<td>8.8</td>
<td>8.5</td>
<td>8.8</td>
<td>8.5</td>
<td>8.5</td>
<td>8.7</td>
</tr>
<tr>
<td>O2 - Sättigung (BGA) %</td>
<td>82.9</td>
<td>94.7</td>
<td>79.0</td>
<td>96.5</td>
<td>95.1</td>
<td>95.9</td>
<td>78.6</td>
<td>97.7</td>
</tr>
<tr>
<td>BE mmol/L</td>
<td>10.4</td>
<td>3.7</td>
<td>4.0</td>
<td>2.4</td>
<td>1.3</td>
<td>2.7</td>
<td>3.1</td>
<td>2.2</td>
</tr>
<tr>
<td>HCO3- mmol/L</td>
<td>31.3</td>
<td>26.5</td>
<td>26.8</td>
<td>25.6</td>
<td>24.2</td>
<td>25.7</td>
<td>26.0</td>
<td>25.6</td>
</tr>
<tr>
<td>Kalium mmol/L</td>
<td>3.91</td>
<td>4.68</td>
<td>4.73</td>
<td>4.34</td>
<td>4.17</td>
<td>4.09</td>
<td>4.83</td>
<td>5.39</td>
</tr>
<tr>
<td>Natrium mmol/L</td>
<td>139</td>
<td>143</td>
<td>139</td>
<td>138</td>
<td>140</td>
<td>138</td>
<td>139</td>
<td>141</td>
</tr>
<tr>
<td>Calcium (ion.) mmol/L</td>
<td>1.19</td>
<td>1.20</td>
<td>1.10</td>
<td>1.08</td>
<td>1.17</td>
<td>1.12</td>
<td>1.18</td>
<td>1.20</td>
</tr>
<tr>
<td>Chlorid mmol/L</td>
<td>107</td>
<td>102</td>
<td>105</td>
<td>106</td>
<td>106</td>
<td>107</td>
<td>104</td>
<td>104</td>
</tr>
<tr>
<td>Glucose mg/dL</td>
<td>63</td>
<td>177</td>
<td>275</td>
<td>238</td>
<td>138</td>
<td>153</td>
<td>200</td>
<td>198</td>
</tr>
<tr>
<td>Lactat mmol/L</td>
<td>0.9</td>
<td>1.4</td>
<td>1.4</td>
<td>1.5</td>
<td>0.6</td>
<td>0.7</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Kreatinin (BGA) mg/dL</td>
<td>0.89</td>
<td>0.87</td>
<td>0.83</td>
<td>0.83</td>
<td>0.83</td>
<td>0.82</td>
<td>0.85</td>
<td>0.83</td>
</tr>
<tr>
<td>AaDO2 mmHg</td>
<td>89.0</td>
<td>111.8</td>
<td>......</td>
<td>......</td>
<td>24.9</td>
<td>25.1</td>
<td>18.2</td>
<td></td>
</tr>
<tr>
<td>pO2(a,T) / FiO2 mmHg</td>
<td>268</td>
<td>210</td>
<td>315</td>
<td>363</td>
<td>390</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pronounced observations, manually marked by clinicians
Repeated requirements from clinical users

- latest creatinine? ✓
- latest 3 from creatinine? X
- basic calculations (CNT, MAX, SUM)? ✓
- filter by time? ✓
- filter by value? X
- pronounced observations only? X
- mark values for integration? X
- conditional sections (e.g. isolation)? X
- advanced calculations (trends, scores, …)? X
- conditional formatting? X
- tables and graphs? X
What is possible with limited effort – medication example

**Aktuelle Medikation:**

**Perfusoren Herz-Kreislauf:**
- Norepinephrin 5mg in 50ml; Laufrate: 1ml/h; i.v.

**Perfusoren Analgetika / Sedativa:**
- Metamizol 5g in 50ml; Laufrate: 2ml/h; i.v.

**Perfusoren Sonstige:**
- Heparin 10000i.E. in 50ml; Laufrate: 0ml/h; i.v.

**Analgetika / Sedativa:**
- Piritramid i.v. 3mg i.v. n.B.

**Medikamente: i.v.:**
- Pantoprazol i.v. 40mg; Uhrzeit: 20:00--Uhr
- Furosemid i.v. 20mg; Uhrzeit: 18:00-0:00-6:00-12:00Uhr
What about e.g. chronological patient data?

- Discrete and continuous orders (ranges, sub-ranges)
- Complex substitution, opaque for clinicians
- Hard to master without knowledge of data model
Clinical Decision Support with the Arden Syntax

- MLMs $\rightarrow$ CONDITION-ACTION rules

- **CONDITION**
  - Patient overventilated

- **ACTION**
  - Icon notification

set icon
Arden Syntax suitable for document generation?

- Straightforward, tailored to medical domain

  LATEST 3 FROM creatinine
  MEDIAN OF heartrate

- MLMs create small alert messages → unnamed placeholders

  (patname, meldscore) FORMATTED WITH
  "Patient %s has MELD of %d"
  Patient John Doe has MELD of 28"

- Works for short messages, not large documents
Providing named placeholders with operators

- Experimental Arden Syntax version: PLAIN
- Named placeholders with operators
  …
  IF EXISTS leukozyten THEN WRITE

"Letzter Leukozytenwert: ${latest of leukozyten} /nl am ${time of latest of leukozyten}";

ENDIF;
…

- Formatting with @blue, @bold, …
Is that really a workable solution?

- Use case: phenotyping, trial on antimycotics (Detail)

```
Station: l01, Aufnahmenummer: [redacted], Patientennummer: [redacted]
Aufnahme Intensivstation am 31.12.2018 05:32, Patient ist noch auf Station
Letzter Leukozytenwert: 15.56 /nl am 09.01.2019 05:50
Gabe von Antimykotika erfolgte 3 mal über einen Zeitraum von 2 Tage 20 Minuten
- Anidulafungin i.v. am 07.01.2019 17:40
- Anidulafungin i.v. am 08.01.2019 18:00
- Anidulafungin i.v. am 09.01.2019 18:00
```

- Very basic approach, more of a starting point

- But: low entry barrier, report created in minutes → beats previous tool already now
How clinicians perceive healthcare IT

- Video *EHR State of Mind*

Catch me on the phone with IT, beggin’ tech support

Shoot, it’s like IT and me be stuck in 1994

Innovation all around, but it ain’t in healthcare

Internet and apps for you, but we get ancient software

https://www.youtube.com/watch?v=xB_tSFJsjsw
A personal vision for healthcare IT of the future

- Present often rather reminds of the past
- Institutions depend on vendors ("stuck with EHR")
- IT systems "programmable" (even by clinicians?) → less dependency on vendors, modern systems
- Recommendation: Medical Informatics language with building blocks, @table, @lineplot, @treeview,…
Computer-linguistic, ontology-based approaches for improved language quality

- Besides NLP there is also NLG
- Template-based approach has limitations

"Left atrium moderately enlarged, left ventricle mildly enlarged, right atrium moderately enlarged, right ventricle mildly enlarged"

"Mild to moderate enlargement of all cavities"

- Expert: Dirk.Hueske-Kraus@philips.com, suregen
When will the future start?
Monday, 8:00!

Questions?

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