

Data-Driven Product Design

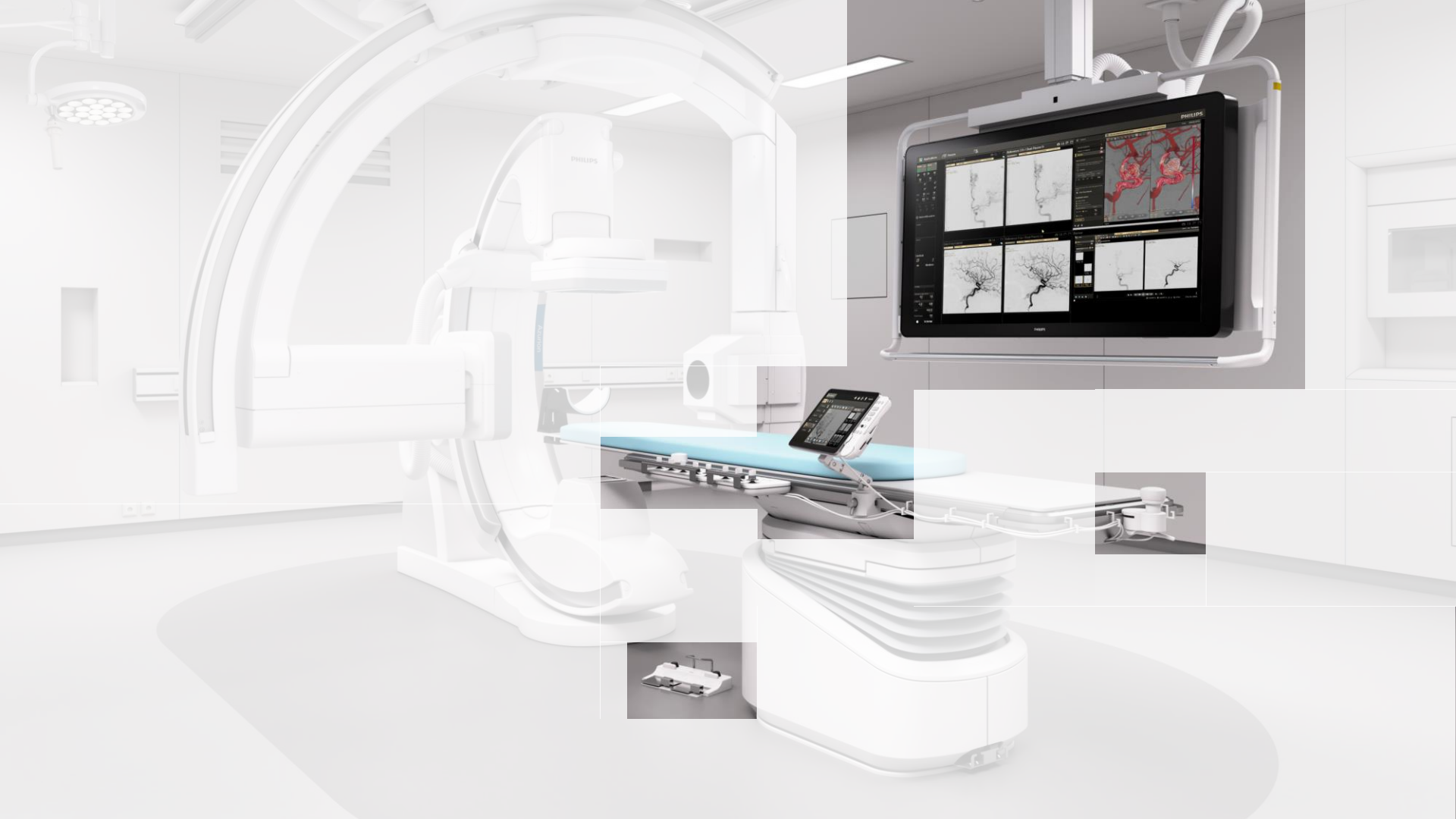
Analyzing use patterns and their context from the data of X-ray systems

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System Designer @ Philips IGT Systems R&D

October, 2019





AGENDA

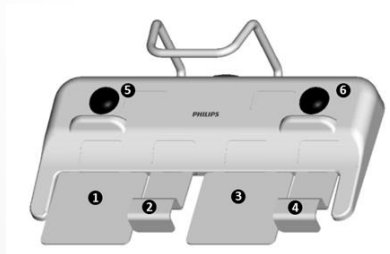
1. **Project context & research goal**
2. **Discover use patterns & detect occurrence context**
3. **Insights & conclusions**
4. **Discussion**

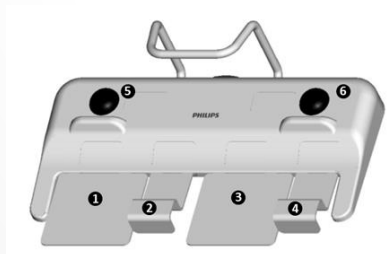


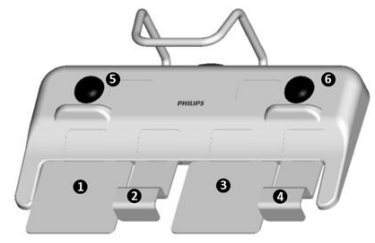
**I am a doctor. You need to keep me and my patients safe.
Design a system that enables me to effectively treat my patients.**

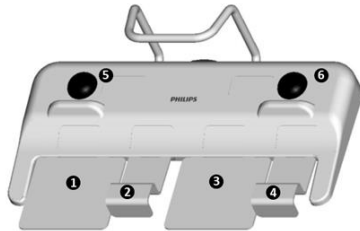


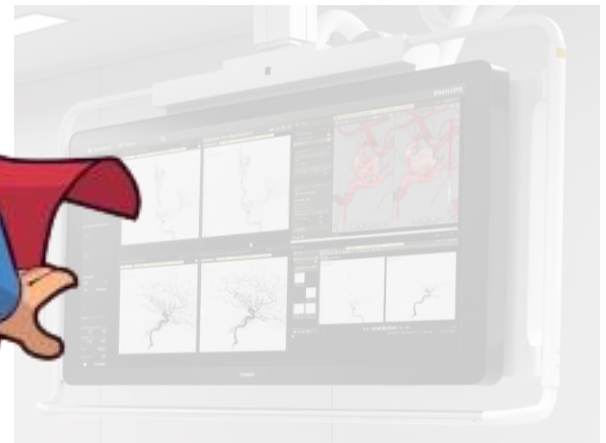
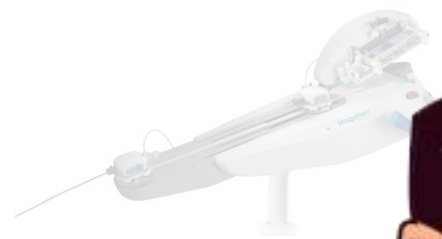












THE STUDY OF **USER BEHAVIOR**

Product Design Process

Limitations of current approaches

1

USABILITY STUDIES

Designed only on existing knowledge
A limited number of specialists / scenarios

2

PHYSICAL PRODUCT MONITORING & FQS TOURS

Solving problem instances
Scattered knowledge

3

CUSTOMER COMPLAINTS

Reported mainly for system related critical events
Scattered knowledge
Unknown scale of impact

Data-driven approach

BIGGER SCALE OF IMPACT

Perform cross-analysis:

How other users, in other hospitals, in other countries are experiencing the same/similar problem

Usability Engineers
assign priorities

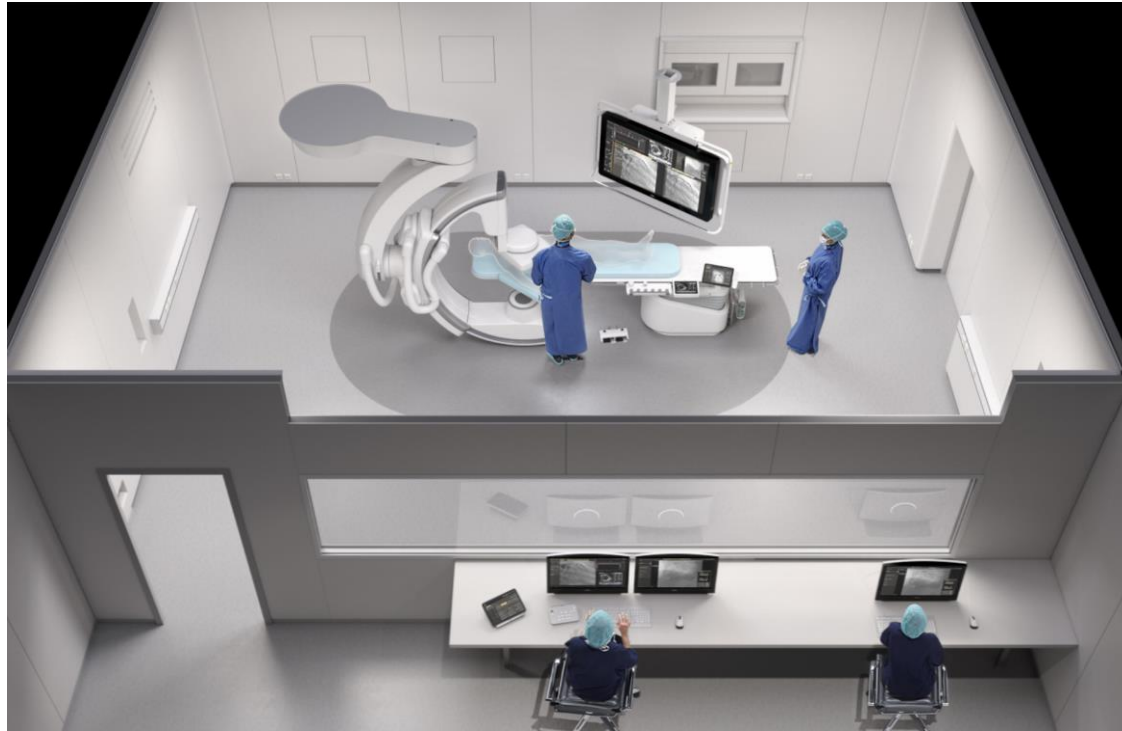
LOOK AT THE REASONS OF A SPECIFIC USER BEHAVIOR

What leads to it?

In which context does it occur?

WHICH **SYSTEM** ARE WE FOCUSED ON?

Interventional X-Ray Systems (iXR): Philips Azurion



● Exam Room

● Control Room

DISCOVER **POTENTIAL FOR AUTOMATION**

Why does it matter?

As humans ...

1

Tend to forget

Skipped actions

2

Perform actions as habit

Wrong actions

3

Need to memorize & think

Annoyance & frustration



So...

USER EXPERIENCE

Avoid unnecessary interactions
Reduce cognitive load (need to think & remember)
Reduce frustration and annoyance
Spend more time on meaningful things

SAFETY REQUIREMENT


Ensure Safety Requirements
By avoiding skipped /wrong actions

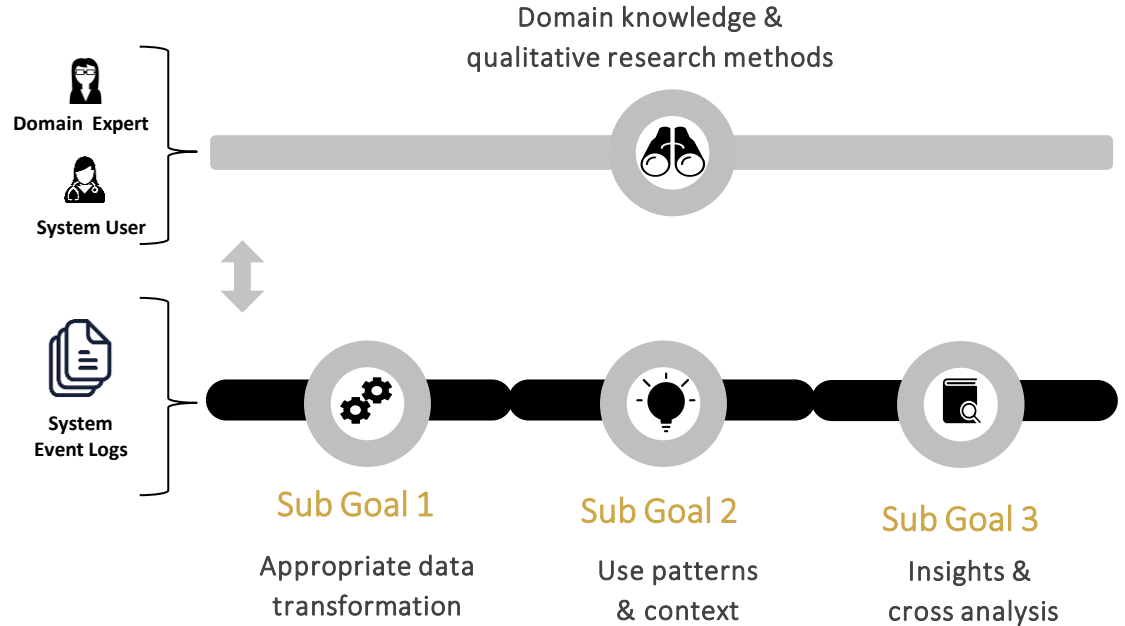
RESEARCH GOAL



Given a system event log, how can the product design be improved by identifying user behavior which might represent a potential for automation in a specific occurrence context?

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RESEARCH GOAL

Domain knowledge & qualitative research methods



1

Find a **relevant way to transform the data**, such that it allows *discovering user behavior* that potentially represent a need for automation and *making use of contextual information*.



Sub Goal 1



Sub Goal 2



Sub Goal 3

RESEARCH GOAL

Domain knowledge & qualitative research methods

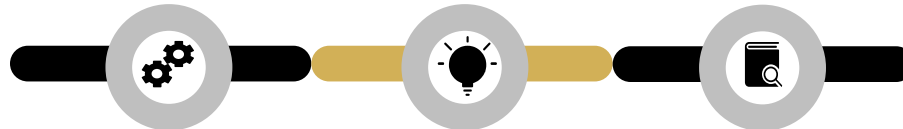


2

Discover use patterns that might represent a potential for automation and **detect the context** in which a given use pattern occurs.

Pattern: expected desired use of the system

Anti-pattern: expected undesired use of the system



Sub Goal 1

Sub Goal 2

Sub Goal 3

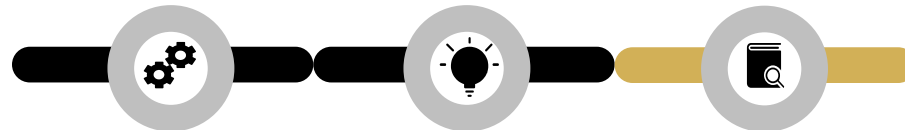
RESEARCH GOAL

Domain knowledge & qualitative research methods



3

Analyze the identified context, detect and **evaluate** the occurrence of the **same or similar use** patterns

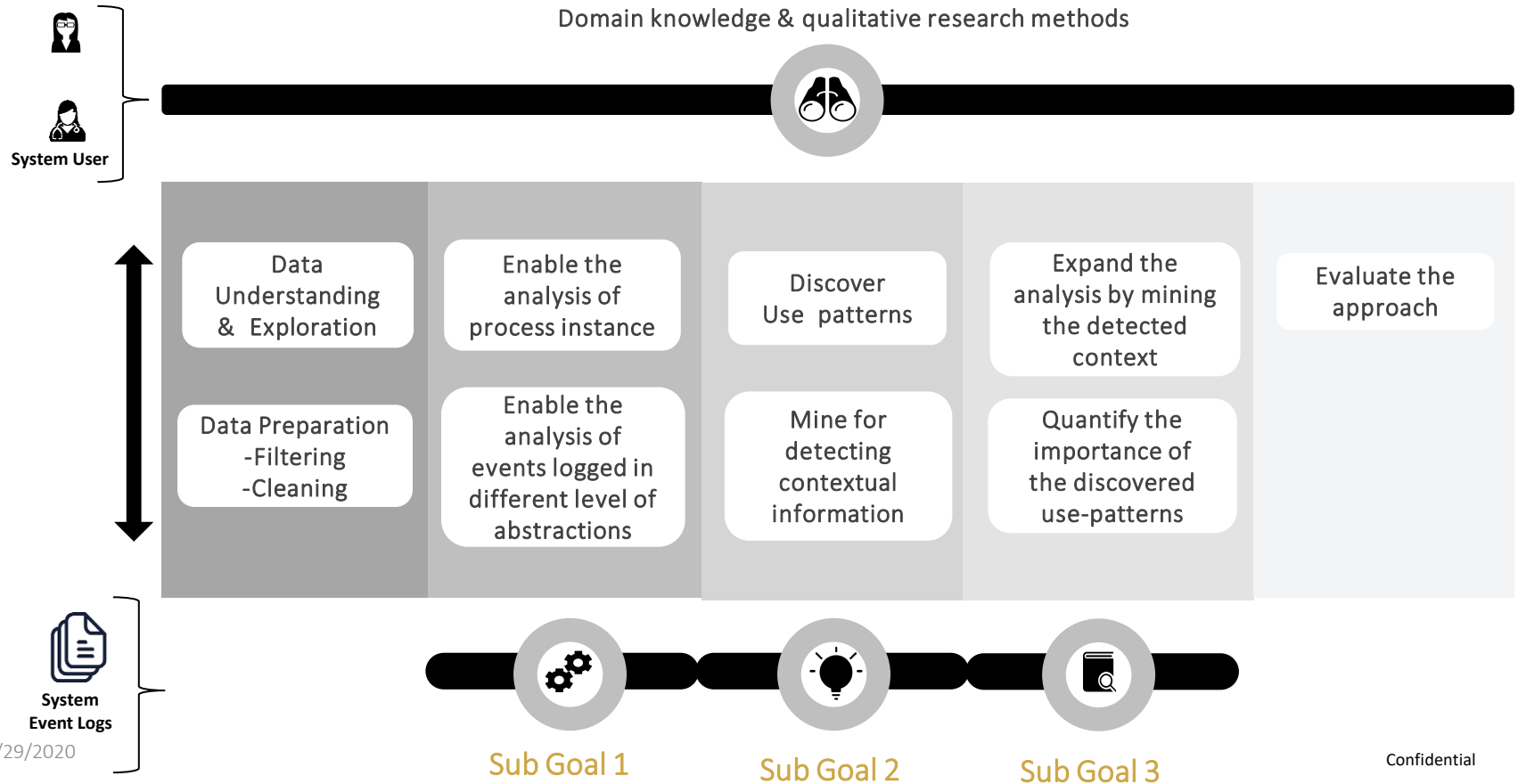


Sub Goal 1

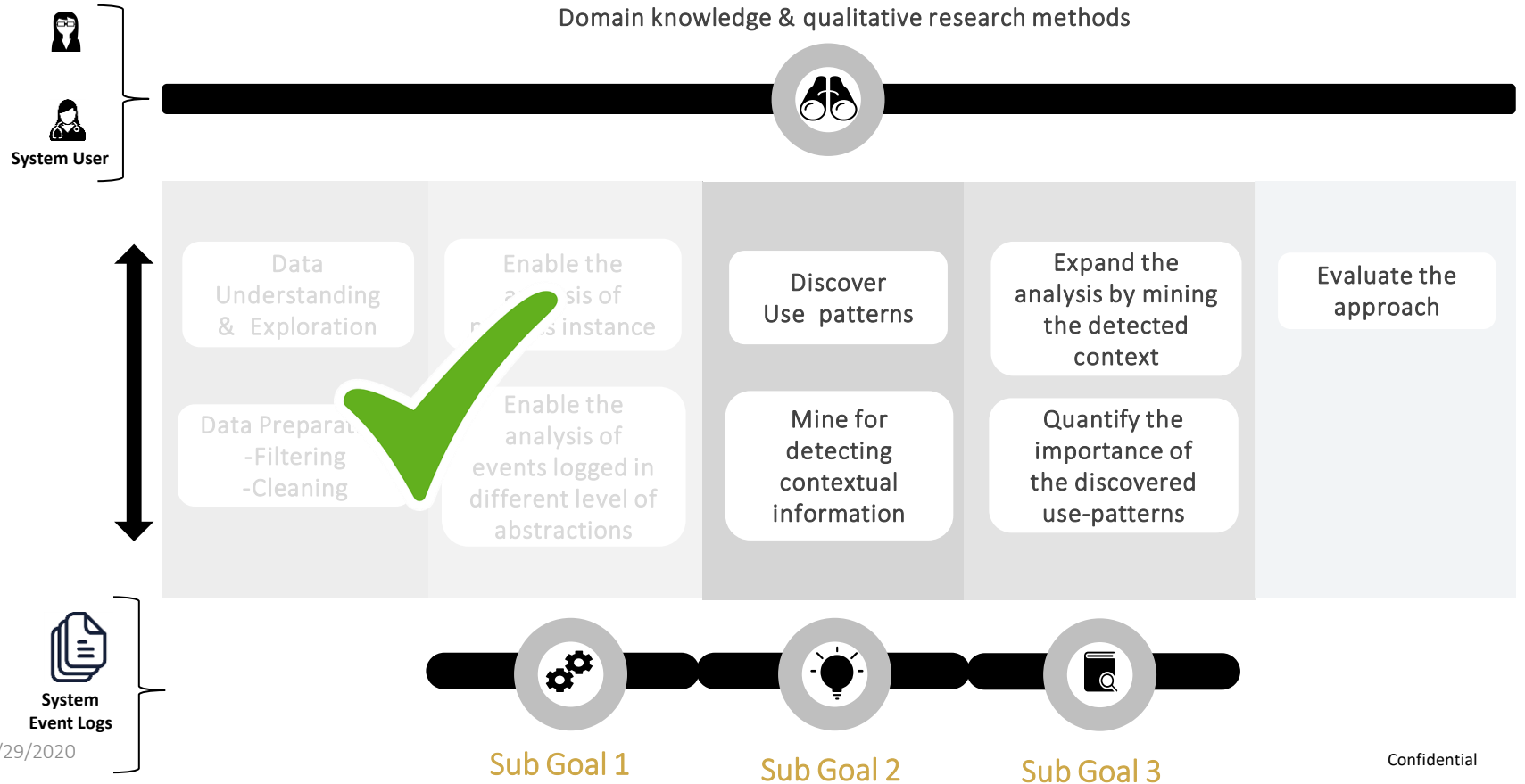
Sub Goal 2

Sub Goal 3

HIGH LEVEL OVERVIEW



HIGH LEVEL OVERVIEW



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HOW DOES THE DATA LOOK LIKE?

- Case → process instance
- Activity → well defined step in the process
- Event → activity related to a specific case
- Trace → sequence of events that belong to one case

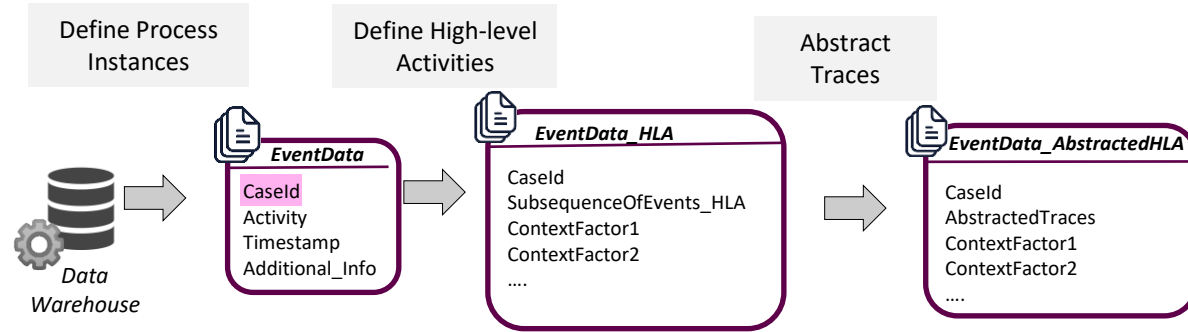
CaseID	Timestamp	Description
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.040	Command: StartFluoroscopy
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.044	Command: StartFluoroscopy
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.051	User output: LED on UI module is set on
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.062	Command: BLDisplayOrientation
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.062	Start prepare generator
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.068	Acquisition -> Prepare devices for Acquisition
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.145	Viewpad: UiActivity detected
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.154	From Generator device: PoInt: Shunt test and calibration data
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.156	XrayService: Prepare
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.202	XrayService: acquisition parameters
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.390	XrayService: Prepared
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.393	Lab: lock
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.406	Lab: display mandatory applications
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.419	Finished preparing detector
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.547	Finished preparing detector
4226704_2018-04-06_15:12:48.169000_DLE	2018-04-06 15:47:05.555	Xray indication inside: On

DISCOVER USE PATTERNS



1 Trace abstraction

Set / Bag abstraction



DISCOVER USE PATTERNS



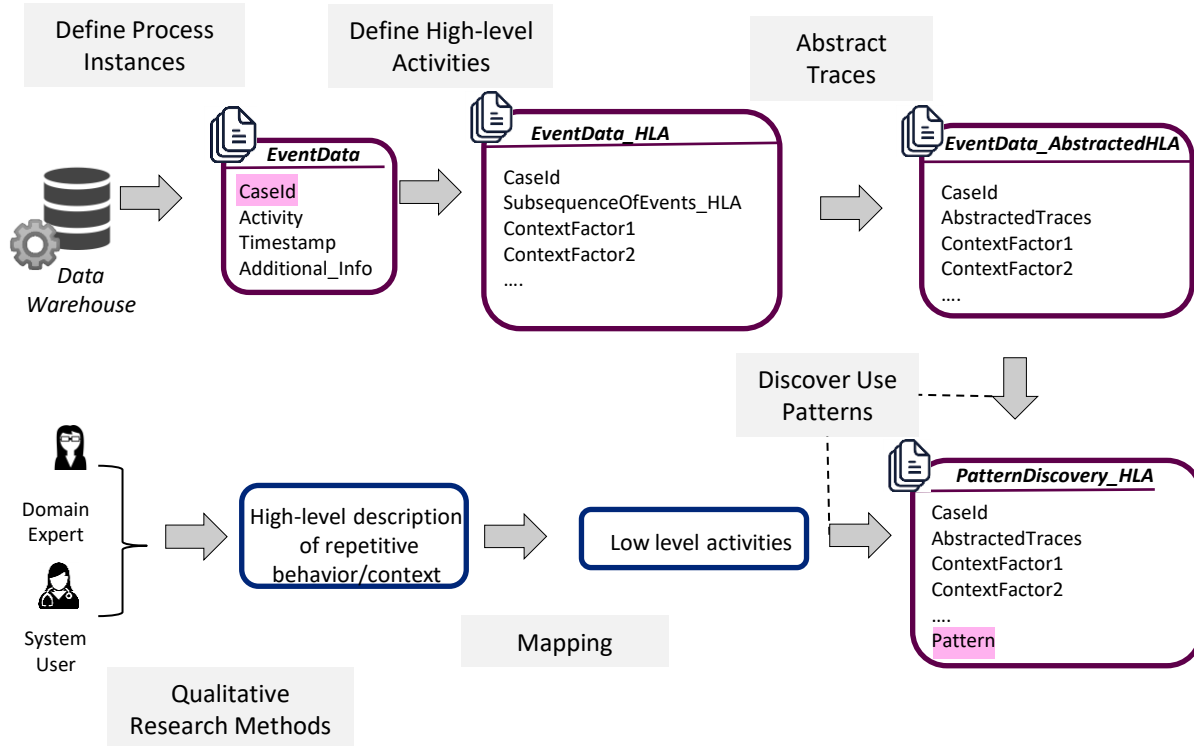
1 Trace abstraction

Set / Bag abstraction

2 Filtering activities

Check if activity occurs in the abstracted trace

SelectReceptorSize
OR
SelectReceptorCommercialSize



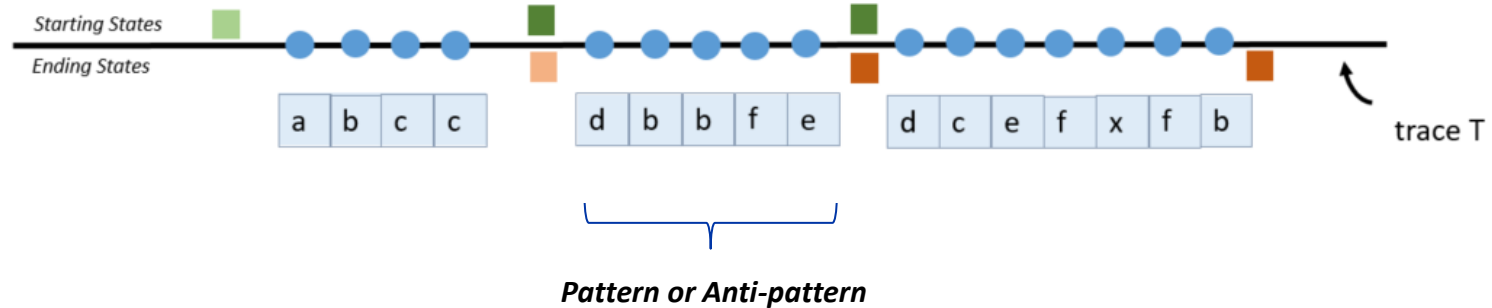
DETECT OCCURRENCE CONTEXT



To evaluate the potential for automation

CONTEXT:

A function over the trace, which can be applied on its prefix or suffix and it is centered on the pattern occurrence
i.e. system settings; time; surrounding events

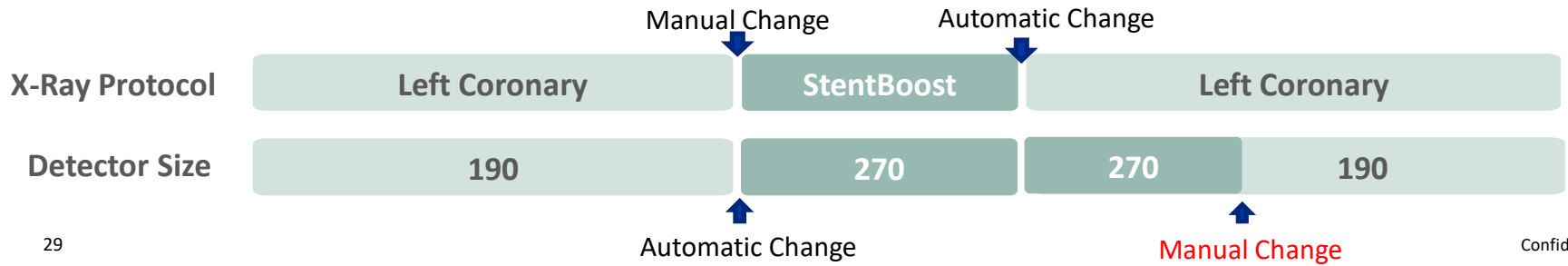
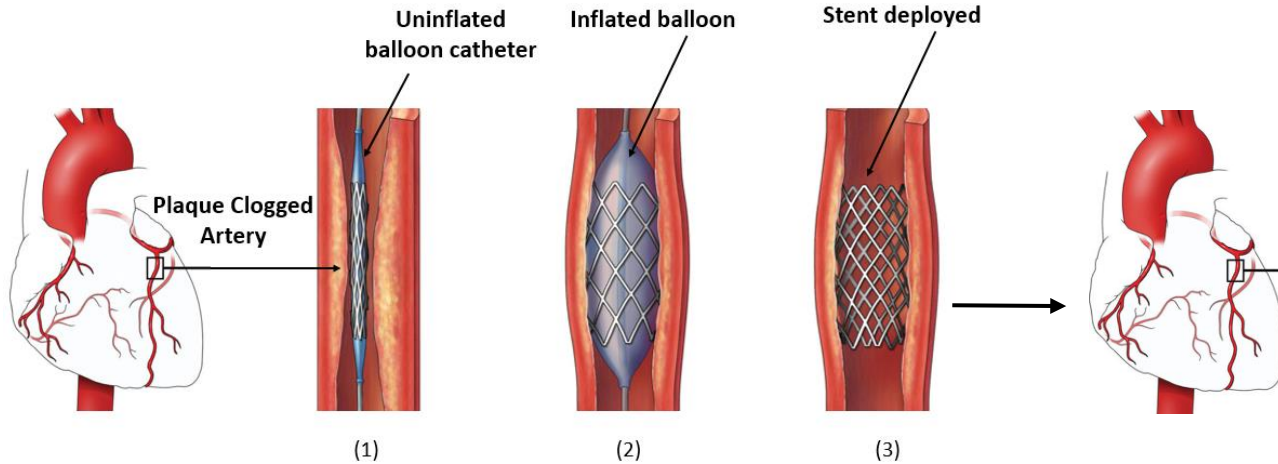


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CASE STUDY

Philips Azurion systems: Manual resize of the detector after the StentBoost acquisition



CASE STUDY

Philips Azurion systems: Manual resize of the detector after the StentBoost acquisition

Data Scope

7 Azurion systems at a hospital in the Netherlands
(only 3 using StentBoost)

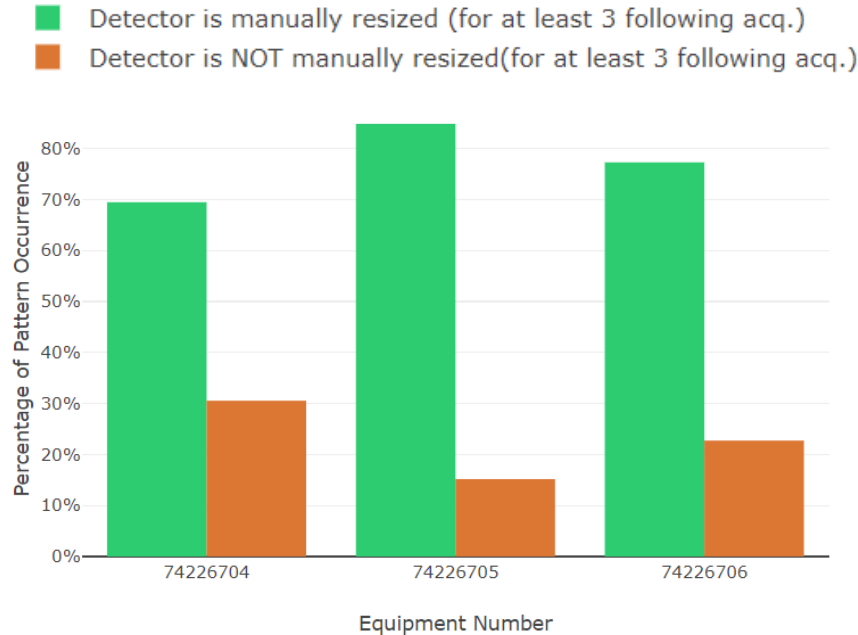
Time Period: 8 months

Observations and interviews



CASE STUDY

How often do they resize the detector manually?



70%, 78%, 85%
of the times a SB is performed, it is followed by a manual change of the detector size, by the clinicians

CASE STUDY

From correlation to causality. When does the manual change occur?



Is there a correlation between severity level of the pattern and the unit used to perform the event?



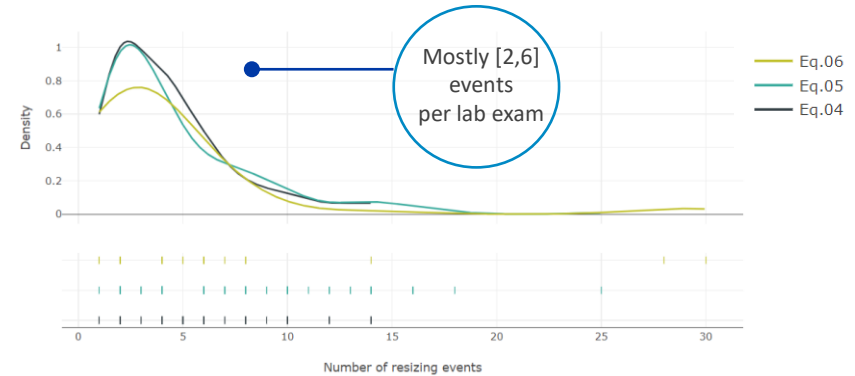
Doctors **VS** Technicians

Behavior based on observations **VS** Learned Behavior

QUANTIFYING THE IMPORTANCE OF THE **DISCOVERED USE PATTERN**

- **Severity Rating**
User Experience & Problem Frequency
- **Scatter Radiation**
- **Image Quality**

What is the probability density of the number of events performed?



	Few users experiencing a problem	Many users experiencing a problem
Small impact on the user experience	Low severity	Medium severity
Large impact on the user experience	Medium Severity	High severity

*Adapted from Nielsen (1993).
Severity rating taking into account problem frequency and impact on the user experience*

EVALUATION

Changes are performed in the affected systems

How do the users react to changes performed in the system, initiated by our project?

1 Data driven evaluation

Data for evaluation: 34 days

Repeat the analysis to detect if there are still occurrence of the discovered use pattern

2 Qualitative evaluation

Observations and interviews in hospitals

DATA-DRIVEN EVALUATION

Evaluate the reaction of users to system changes

Question

Do use patterns still occur after the change in the system?

Is there a difference between learned behavior and behavior based on observation?

How fast do users get used to the system change?

Is there a benefit in terms of the number of the button clicks and exam duration?

Answer

NO, in 99% of the cases

NO difference

**Above our expectations,
immediately!**
There is no error-correction period.

Less button clicks

QUALITATIVE EVALUATION

User reaction to system changes

*How users **experience, find and feel** about the change.*

Question

How do users find the interaction with the system after the change?

Is the system intuitive enough to easily understand and get used to the new configuration or they were told about it?

Answer

Perfect. They really like it.

**Very intuitive.
They were not informed about the change.**

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CONTRIBUTIONS OF THE **PROPOSED APPROACH**

We proved that:

- 1 It is possible to discover use patterns and make use of the contextual information by using **the notion of high-level activities**
- 2 Traditional methods of studying user **behavior can be enhanced** with insights from a data-driven approach, contributing in this way in the product design process

LIMITATIONS OF THE **PROPOSED APPROACH**

Technical

- 1 Assuming a distinguishable start & end state of the high-level activities
- 2 Using trace abstraction, leads to losing the order of the events

LIMITATIONS OF THE **PROPOSED APPROACH**

Organizational

- 1** If it is seen, it cannot be unseen
- 2** Legal, privacy and ethical decisions and standpoints are required to advance in the field

FUTURE USE OF THE **PROPOSED APPROACH**

1 Extend by defining other types of high-level activities

i.e. the phases of clinical workflow

2 Discover other types of user behavior (not only the one representing potential for automation)

i.e. use complaints or FQS tours as initial point

3 Extend to consider concurrency and parallel high-level activities

4 Toward Adaptive Intelligence in Healthcare

We suggest future work to focus more in detecting the detailed context in which specific user behavior occurs



**THANK
YOU**

