Data-driven approach for reproducing use scenario using machine logs

An Azurion case study at Philips IGT System

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PHILIPS innovation you

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4 **Application**
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Future work

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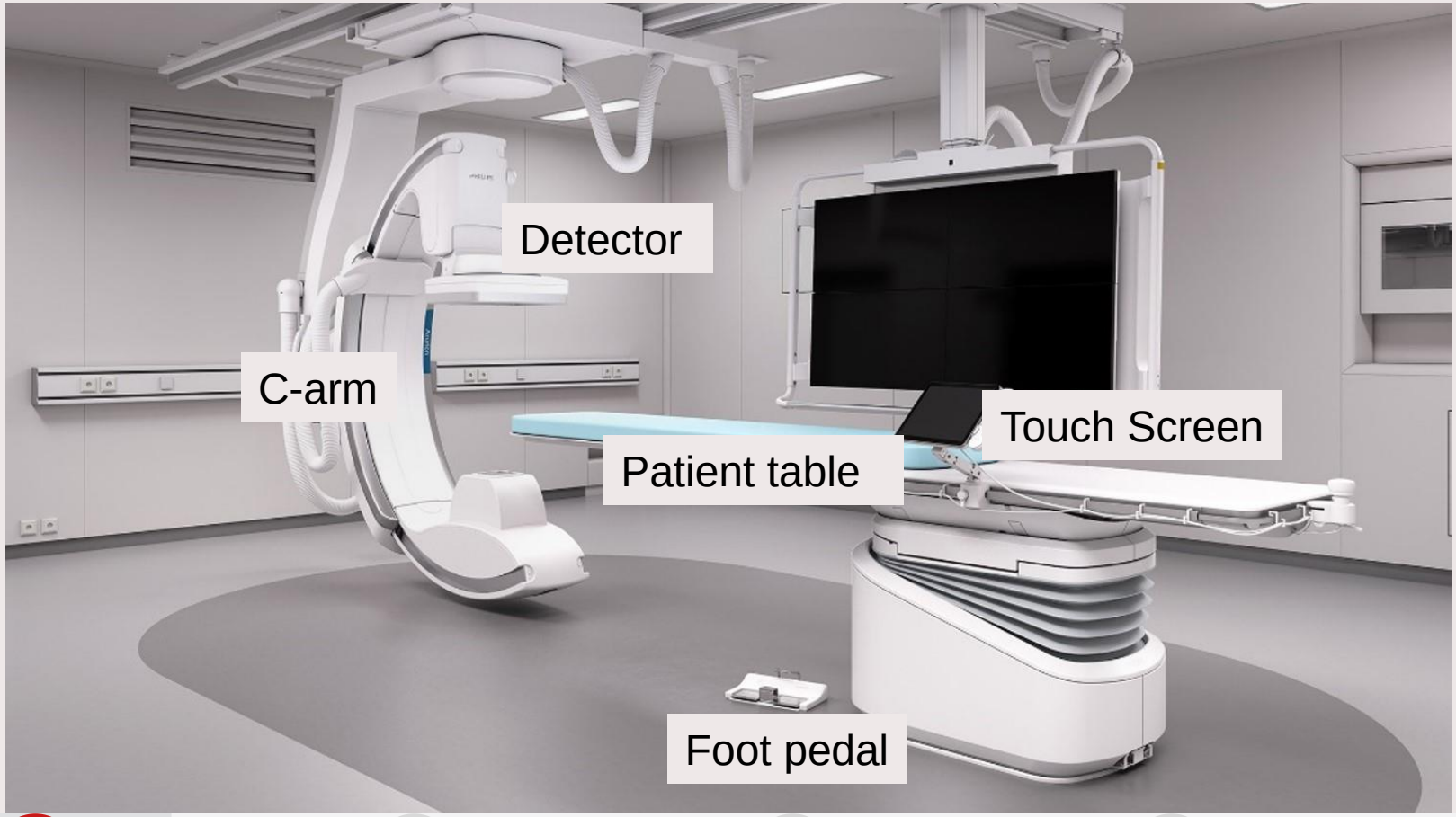
Introduction: Human interactive machine

- Rely on **user's** choices
  - No single standard process
  - Complex and variation

- How to **improve** the user experience of such a machine?
  - User behavior study to reproduce use scenarios
    - Observations: effort
    - Interviews: prepare questions
    - User Feedback: a small subset

  - Machine log
    - Objective record
    - No explicit privacy issue

Case study: Azurion system



- Image-Guided system
- Interventional X-ray machine
- Reproducing use scenario: (X-ray usage)
  - What
  - When
  - Where

Reproducing the use scenario: Challenges

Video

- Time-consuming
  - An exam lasts around 30 mins
- No annotations
  - Manual annotation needed
- Privacy issue
  - Only a few hospitals give permission

Research question

Given a machine usage log, what methodology can reproduce use scenarios such that it can enhance the user behavior study?

Reproducing the use scenario: Hypothesis

Ideally, the presentation of the use scenario can serve as an alternative to video recordings.

- Hypothesis 1: Spatial and temporal information is the key element in reproducing use scenarios for user behaviour study.

- Hypothesis 2: Interactive features are essential for user behaviour study experts to do exploratory data analysis.

Reproducing the use scenario: What do we need?

Hypothesis 1: Spatial and temporal information is the key element in reproducing use scenarios for user behaviour study.

- Geometry movement - spatial
  - Shared room coordinate system
  - Table
  - C-arm
- Exam and X-ray events - temporal
  - All the X-ray events in one exam
  - Ordered by timestamp
  - Metadata on X-ray duration and image protocol

Reproducing the use scenario: First trial

BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU
Position Carm	Position Detector	Position Propellor	Frontal Beam Longitudin	Frontal Beam Transversa	Frontal Rotate Detector	Frontal Swing	Frontal Zrotation	Table Height	Table Lateral	Table Longitudin
10	10100	0	16200	0	-9000	0	-130	9500	-850	8070
10	9940	0	16200	0	-9000	0	-130	9500	-520	7100
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250	10900	5040	16200	0	-9000	0	-130	9500	130	7500
250	10900	5040	16200	0	-9000	0	-130	9500	-60	7500
250	10510	-3070	16200	0	-9000	0	-130	9500	-990	7690
250	10510	-3070	16200	0	-9000	0	-130	9500	-970	7670
250	10050	940	16200	0	-9000	0	-130	9500	-560	7310
250	10820	4690	16200	0	-9000	0	-130	9500	-530	7190
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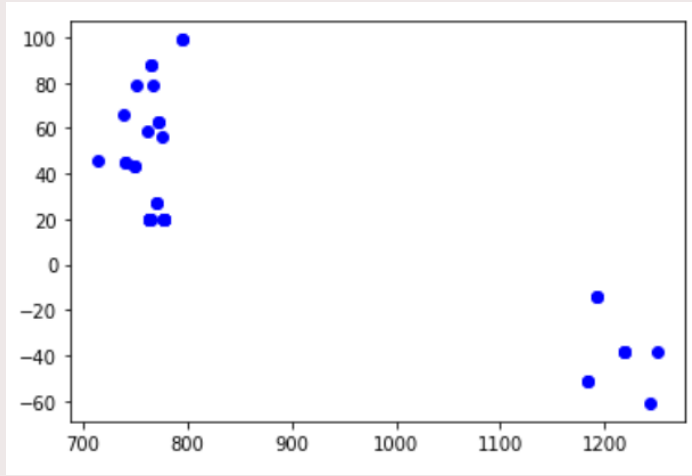
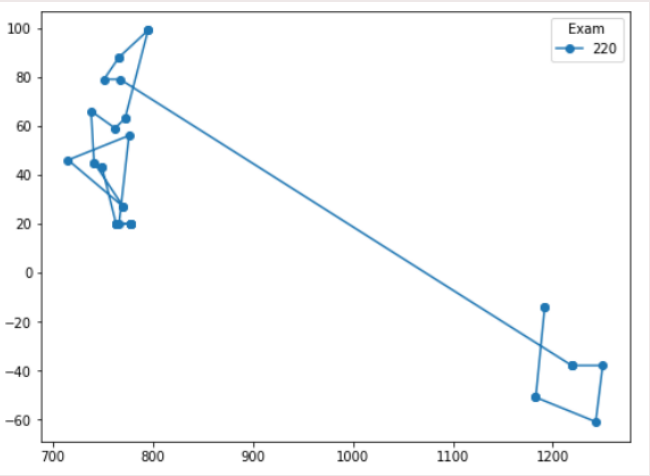
250	10970	4690	16200	0	-9000	0	-130	9500	-510	6890
3090	11870	4890	16200	0	-9000	0	-130	9700	-300	6870
3090	11870	4890	16200	0	-9000	0	-130	9700	-300	6910
1570	11190	-2890	16200	0	-9000	0	-130	9700	-1230	7120
1570	11190	-2890	16200	0	-9000	0	-130	9700	-1310	7400
-70	11140	-3890	16200	0	-9000	0	-130	9700	-1500	7440
-70	11140	-3890	16200	0	-9000	0	-130	9700	-1490	7600
-3750	12020	-1670	16200	0	-9000	0	-130	9040	-900	7370
-3750	12020	-1670	16200	0	-9000	0	-130	9040	-1020	7690
-3250	12090	3840	16200	0	-9000	0	-130	9350	-590	7550
-3250	12090	3840	16200	0	-9000	0	-130	9350	-820	7880





Coordinates and timestamp

Numbers -> where?

Radiation dot

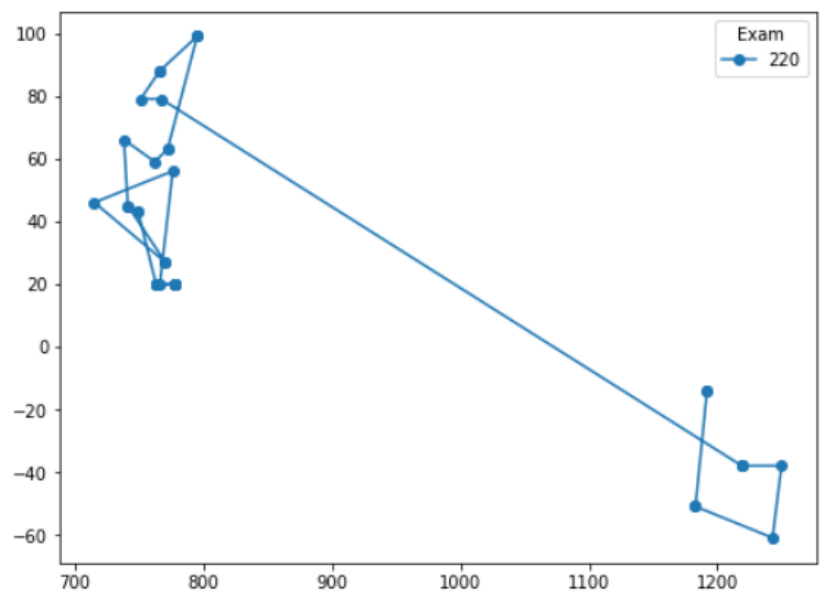
No temporal order involved

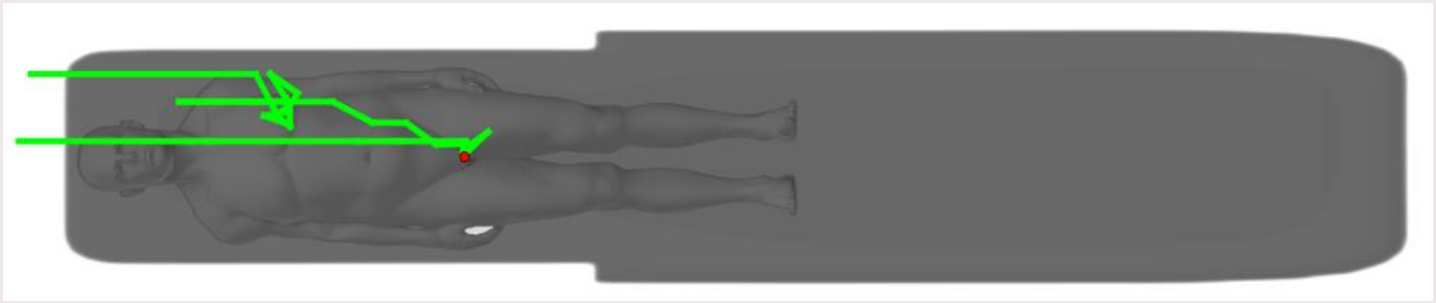
Trajectory

Movement can be viewed

More spatial information?

Reproducing the use scenario: spatial





Static trajectory (top view)

Movement can be viewed

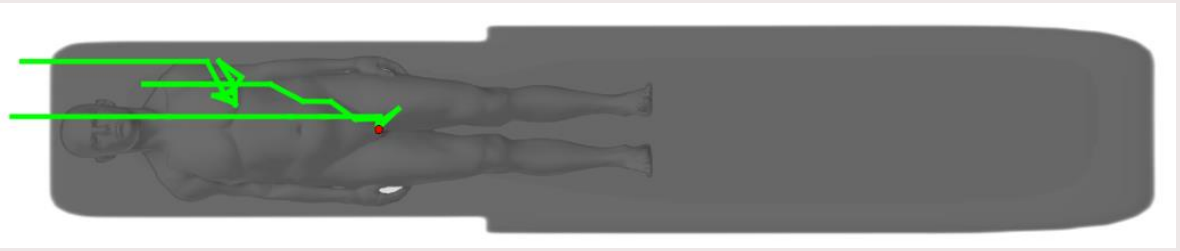
More spatial information?

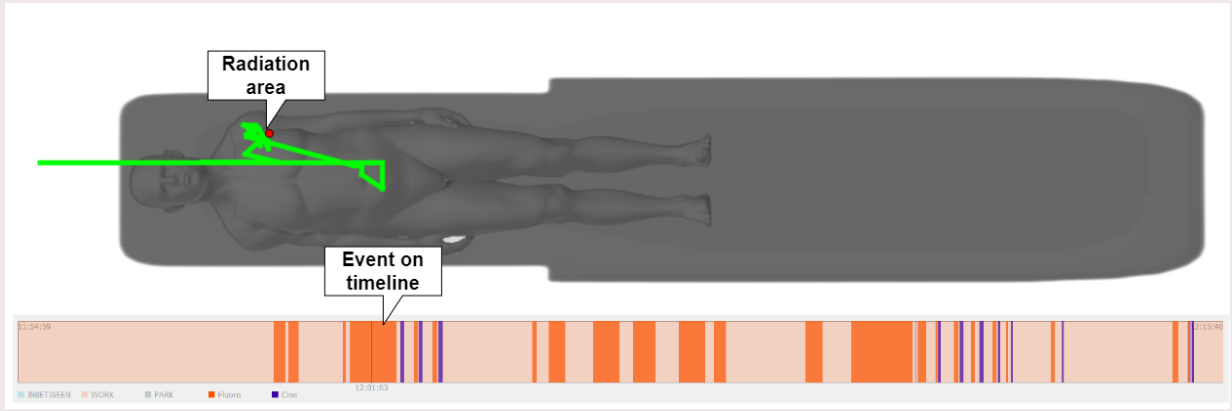
Trajectory on patient body

Radiation area clear

Time order?

Reproducing the use scenario: spatial + temporal





Trajectory on patient body

Radiation area clear

Time order?

Trajectory on patient body with timeline

Process understanding

- Case: process instance
- Activities:
  - Steps in the process
- Event:
  - An activity in a particular case
- Trace:
  - Sequence of all events in a particular case

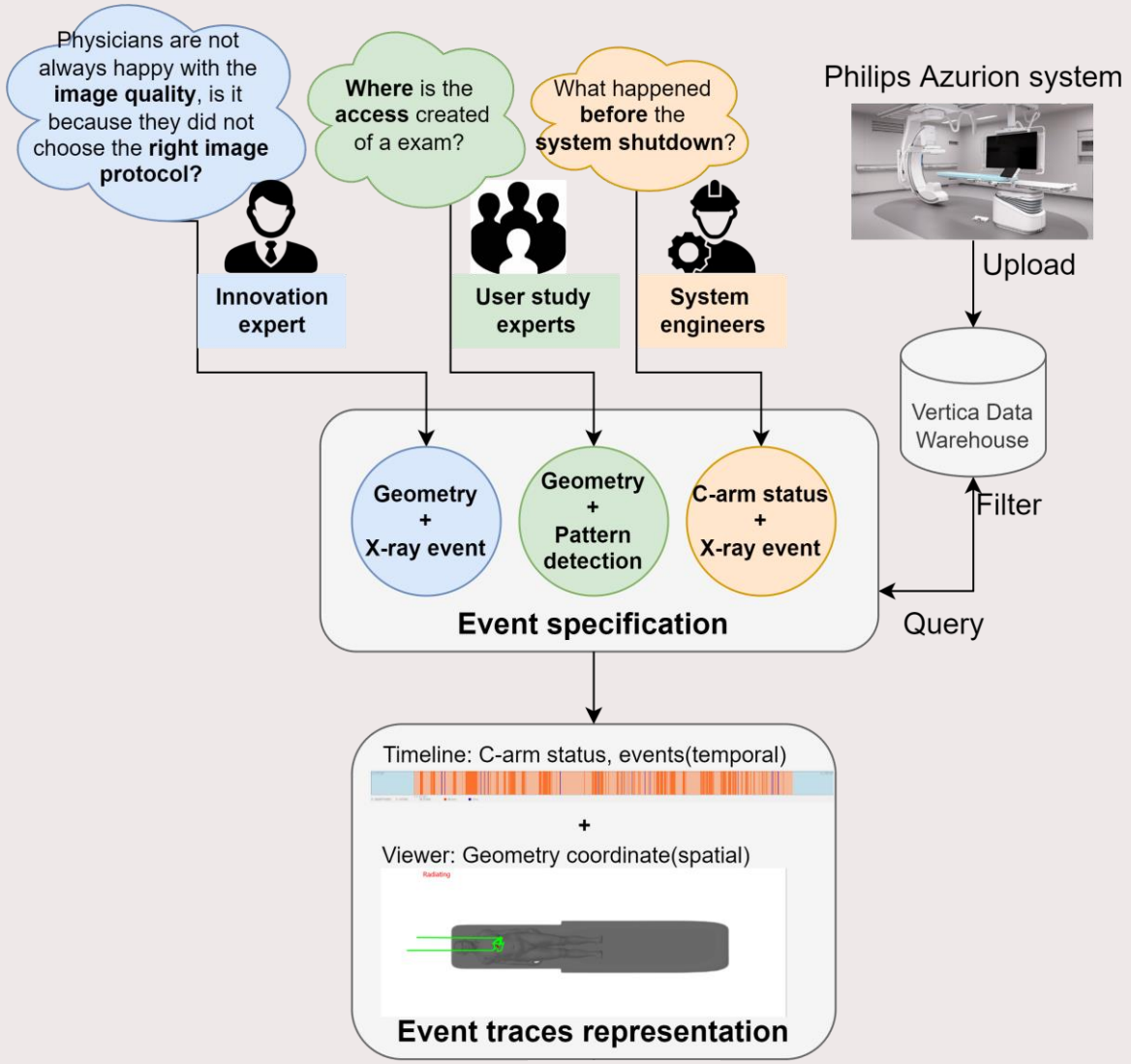
EventId	EventTimestamp	EventDescription
20SSIEC0013000	2021-01-11 08:35:54	Viewpad: UiActivity detected
20SSIEC0001004	2021-01-11 08:35:55	User guidance: X-ray disabled
20SSIGC0009921	2021-01-11 08:39:09	Command: UIActivity
20SSIGC0009921	2021-01-11 08:39:09	Command: StopFluoroscopy
20SSIGC0009921	2021-01-11 08:39:09	Command: StopFluoroscopy
20SSIEC0013000	2021-01-11 08:39:09	Viewpad: UiActivity detected
20SSIEC0012502	2021-01-11 08:42:26	DataHandler: New patient added from RIS
20SSFLV0003503	2021-01-11 08:44:09	Lab: enable snapshot
20SSFLV0003503	2021-01-11 08:44:10	Lab: enable snapshot
20SSIEC0012511	2021-01-11 08:44:10	DataHandler: Start procedure clicked
20SSIEC0012920	2021-01-11 08:44:14	Lab: Exam Selected.
20SSFLV0003502	2021-01-11 08:44:15	Lab: procedure step

Event-based visualization design

Hypothesis 2: Interactive features are essential for user behaviour study experts to do exploratory data analysis.

A flexible, customizable, interactive visualization

1. Users specify their interests or needs
2. Event specification: automatic query and filter data based on user's interests
3. Event trace representation: A visual representation is generated



Implementation: Data flow

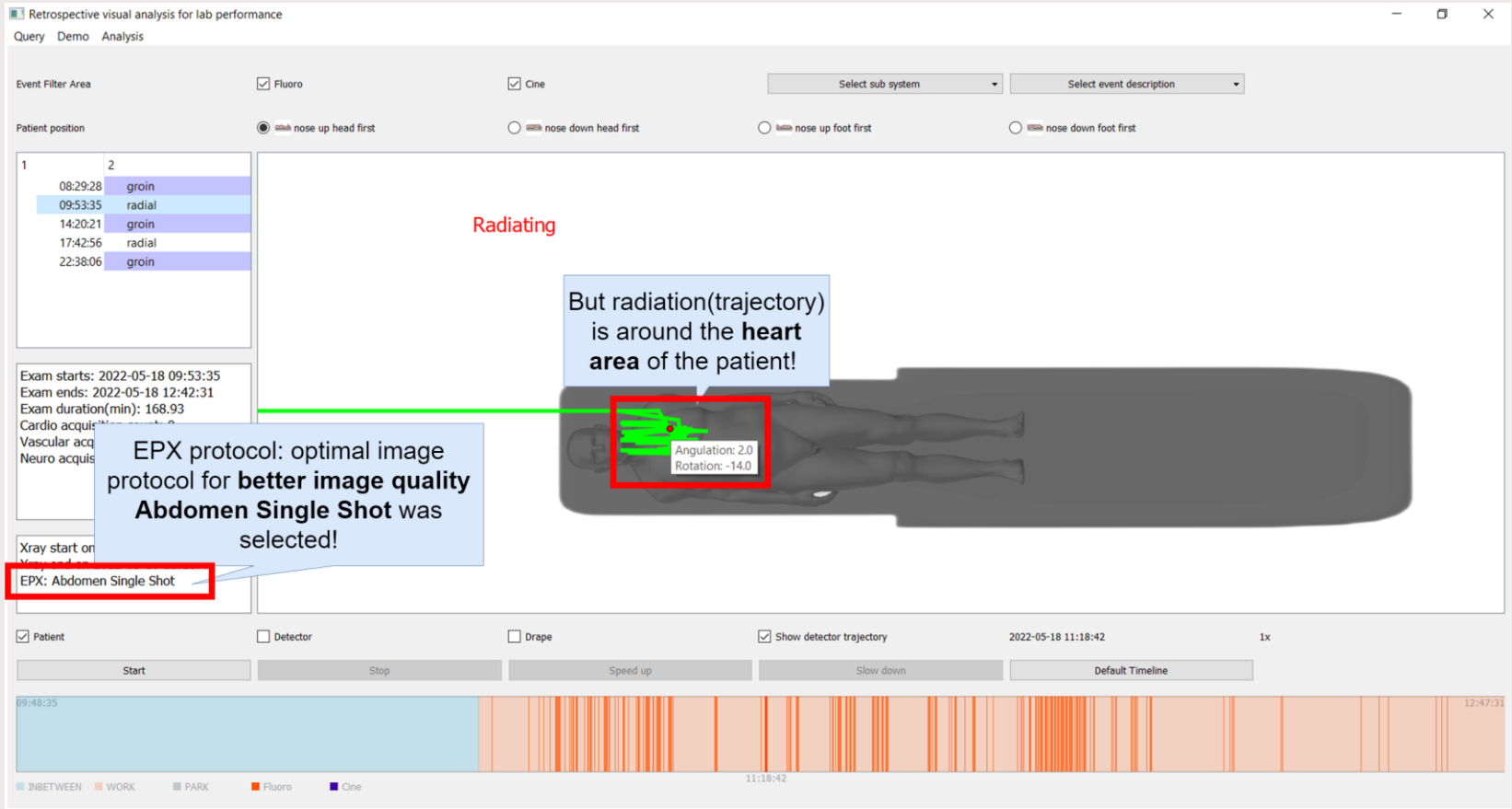
- **Data**: Retrieve machine log from Vertica Data Warehouse
- **UI**: Implemented in Python (PyQt5)

Example persona(1): Innovation expert

Innovation expert

An innovation expert receives feedback on image quality. Thus, he/she wants to see whether this is caused by a wrong image protocol.

Example persona(1): Innovation expert



Innovation expert

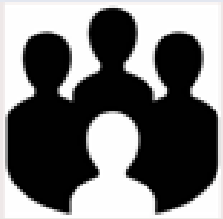
Approach

- An easy and quick individual EPX validation
- Quantification of multiple cases

Value

We understand why the image quality is not always good. Maybe we should investigate the smart image protocol selection…

Example persona(2): User study experts



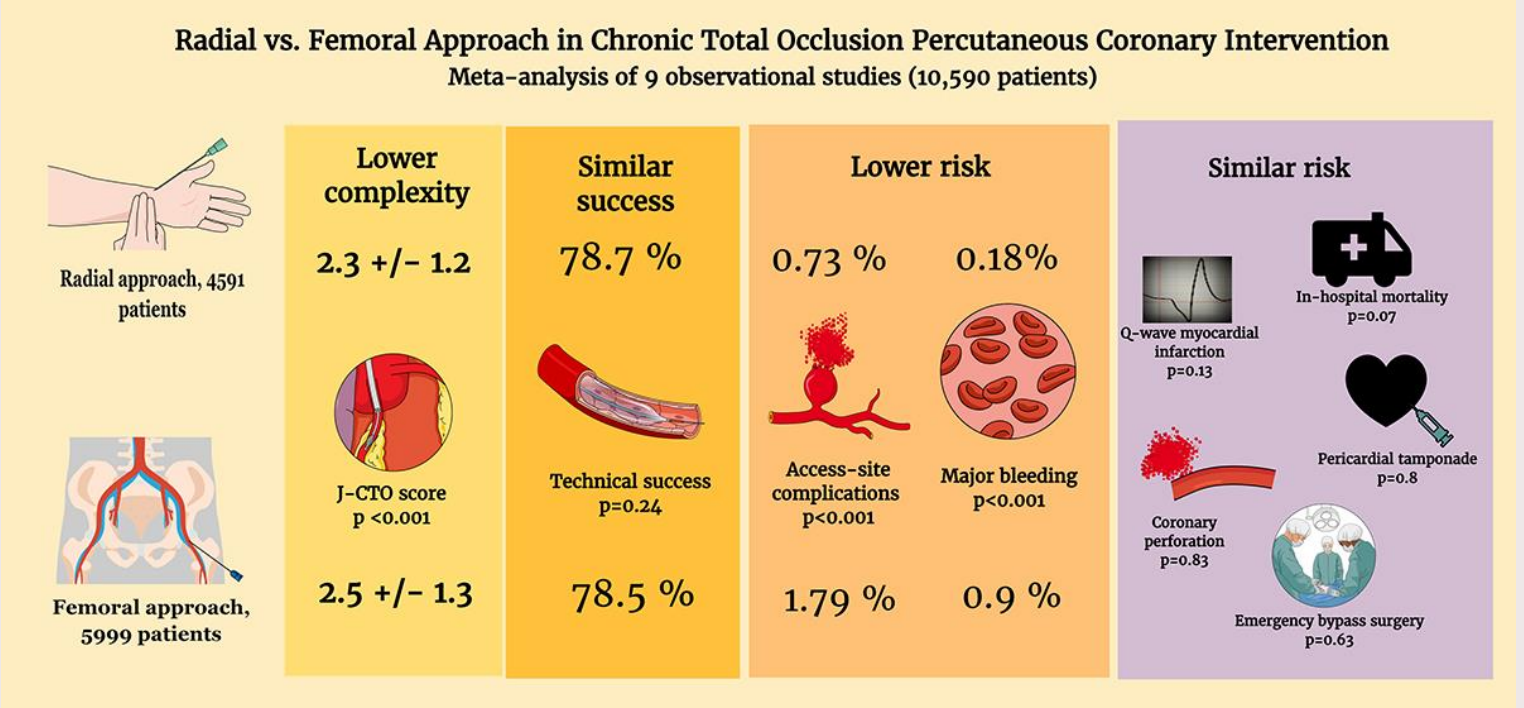
User study experts

A user study group wants to know more about the access creation phase.

Behavior: Clinical access creation – Why

Business

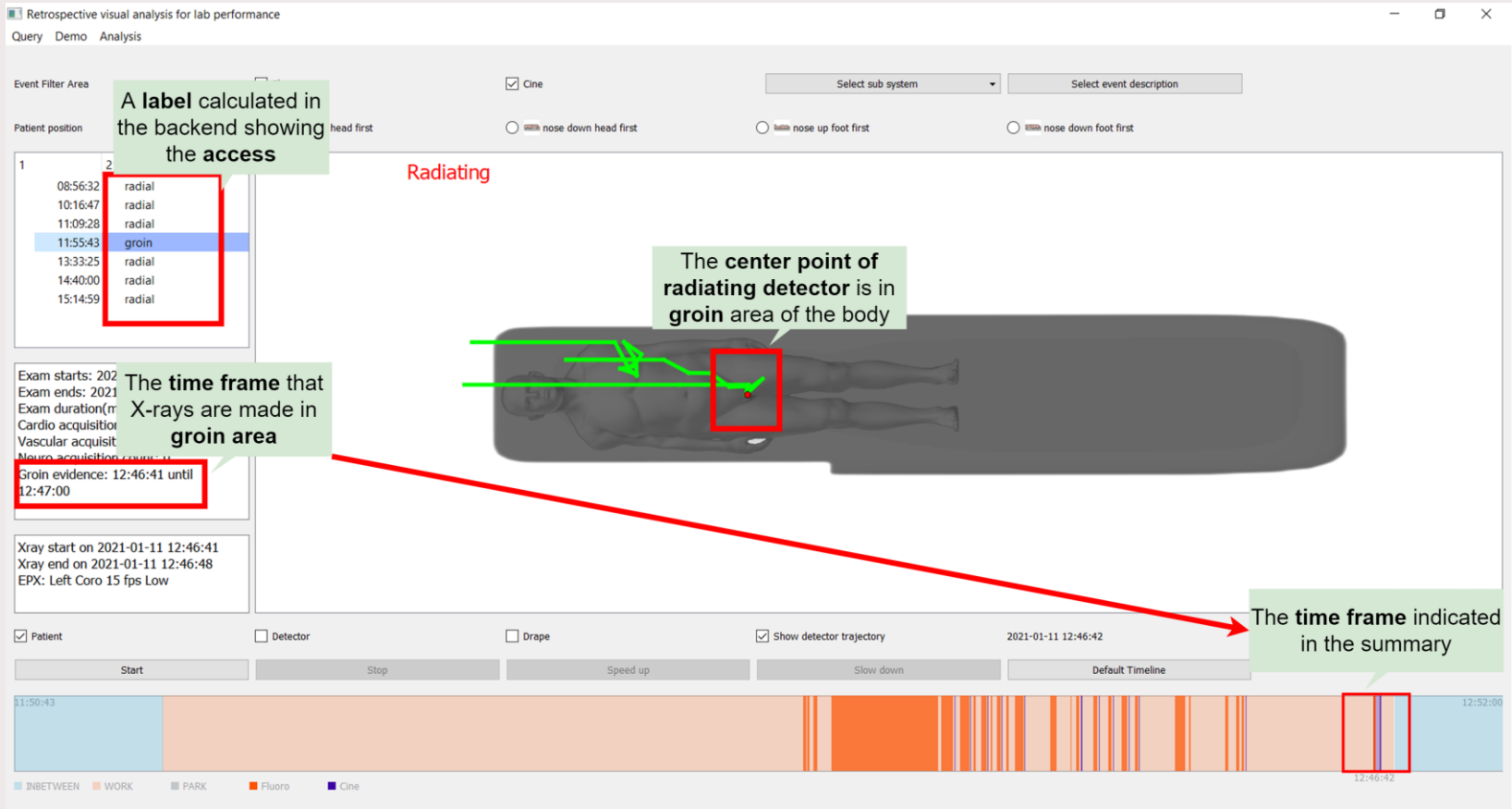
Safety



[1] M. Megaly, A. Karatasakis, B. Abraham, J. Jensen, M. Saad, M.Omer, A. Elbadawi, Y. Sandoval, M. H. Shishehbor, S. Banerjee, et al. Radial versus femoral access in chronic total occlusion percutaneous coronary intervention: a systematic review and meta-analysis. Circulation: Cardiovascular Interventions, 2019.

Example persona(2): User study experts

User study experts



Approach

- Quantification of multiple cases
- Validation(detecting the unique activity) via spatial information

Value

We now can see how many cases are done via radial and femoral access. Reimbursement can be more personalized. We may talk to the lab manager about the physician training…

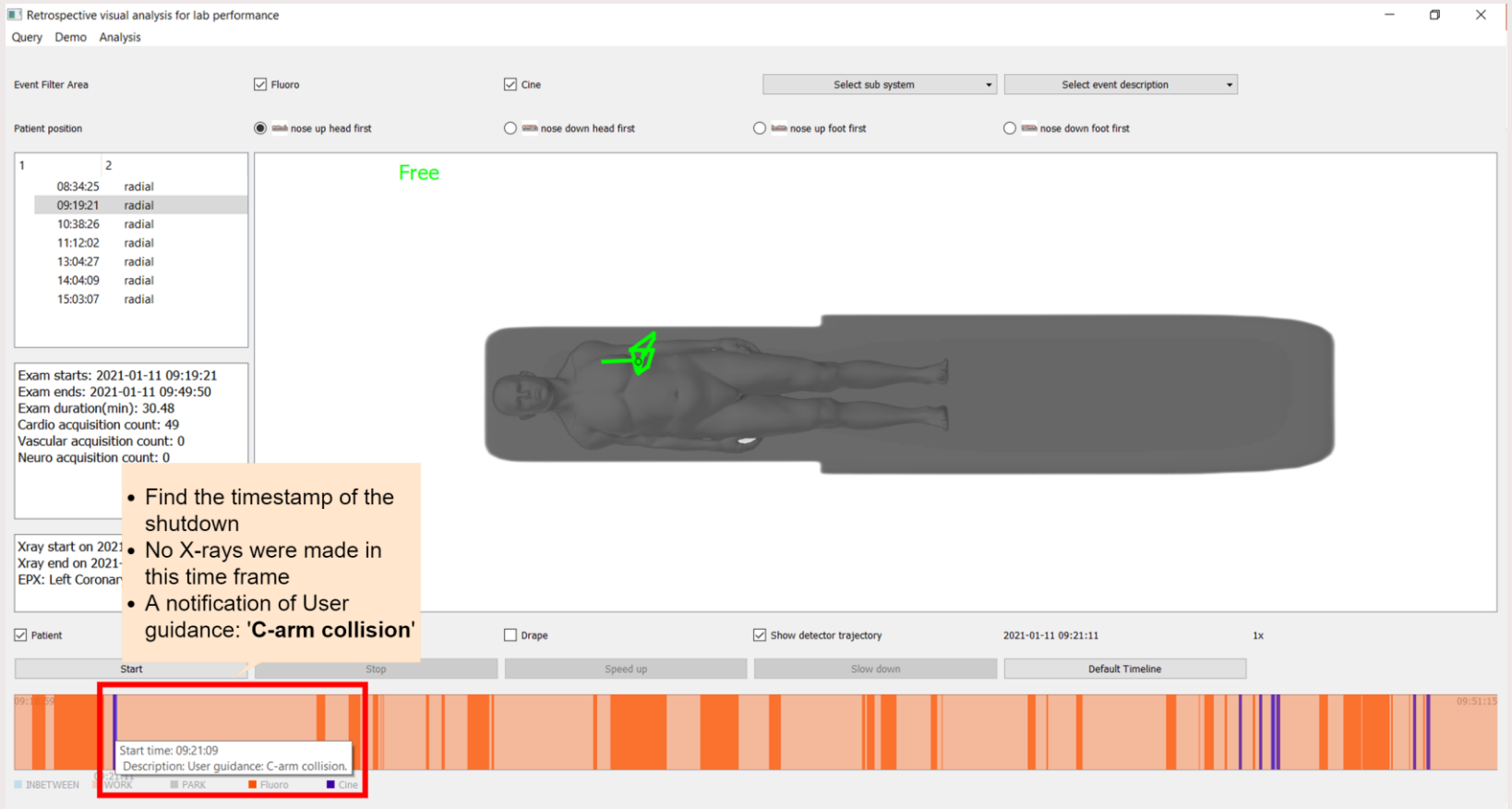
Example persona(3): System engineers

System engineers

A system engineer receives a complaint about a sudden system shutdown at a given timestamp. He/she would like to know what happened before this shutdown.

Example persona(3): System engineers

System engineers



Approach

- Zoom in one case
- All the information within the selected timeframe

Value

We now can see there was a ‘C-arm collision’ before this shutdown. Let’s see whether the collision can lead to a system fault…

Implementation: Comparison

BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU
Position Carm	Position Detector	Position Propellor	Frontal Beam Longitudin	Frontal Beam Transversa	Frontal Rotate Detector	Frontal Swing	Frontal Zrotation	Table Height	Table Lateral	Table Longitudin
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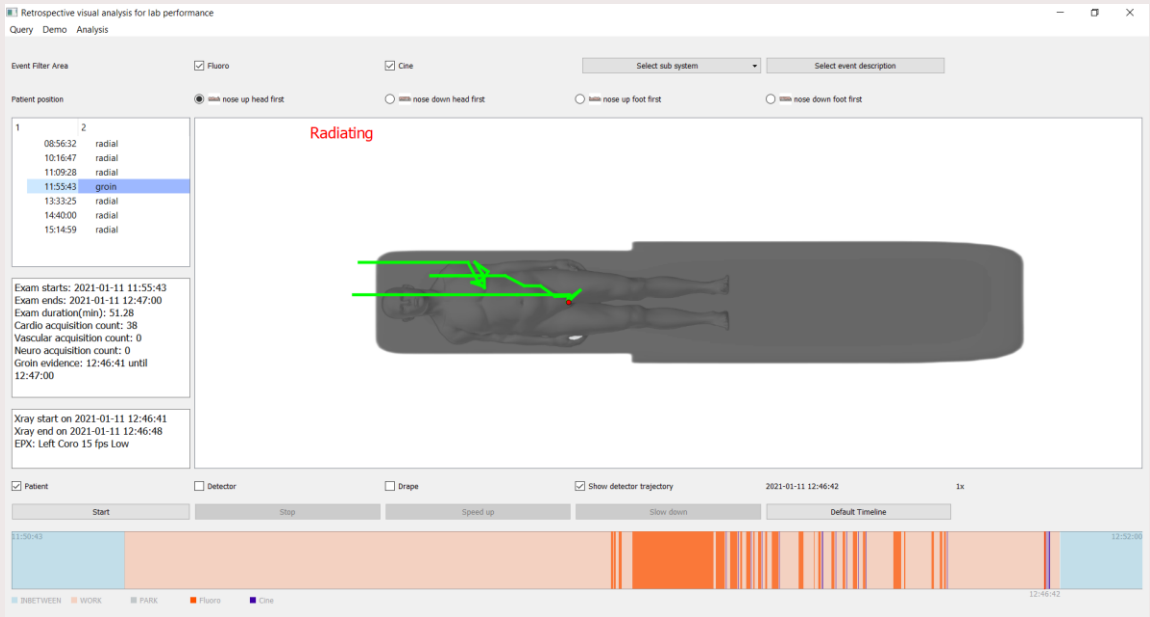
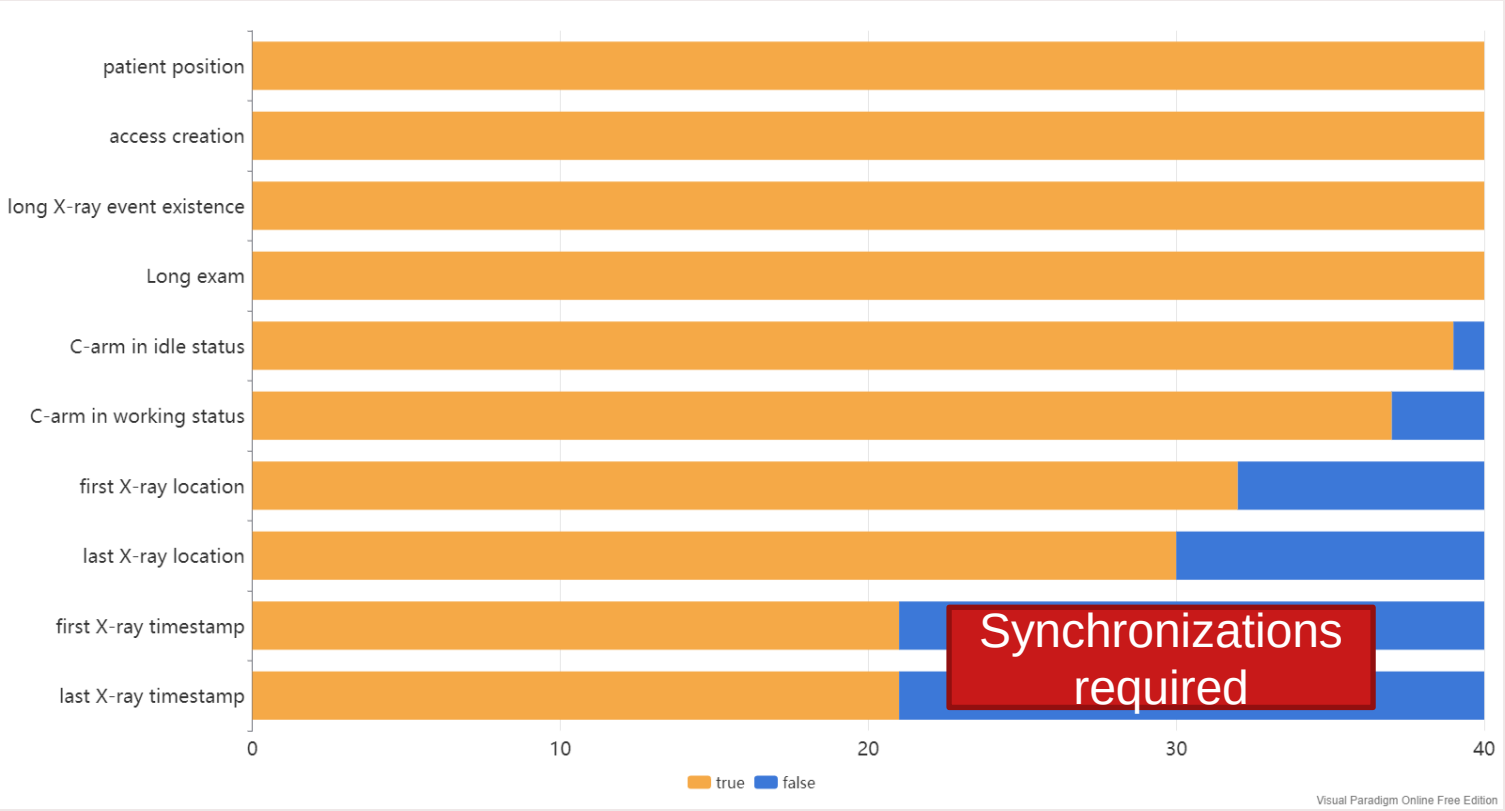


- ☑ Temporal: text ordered by timestamps
- ☒ Spatial information
- ☒ Interactive & Customizable

- ☑ Temporal order: Customizable timeline
- ☑ Spatial: An approximation of the radiation area
- ☑ Interactive & Customizable: Query/Filter/Zoom/…

Evaluation: Correctness - How accurate is the reproduction?

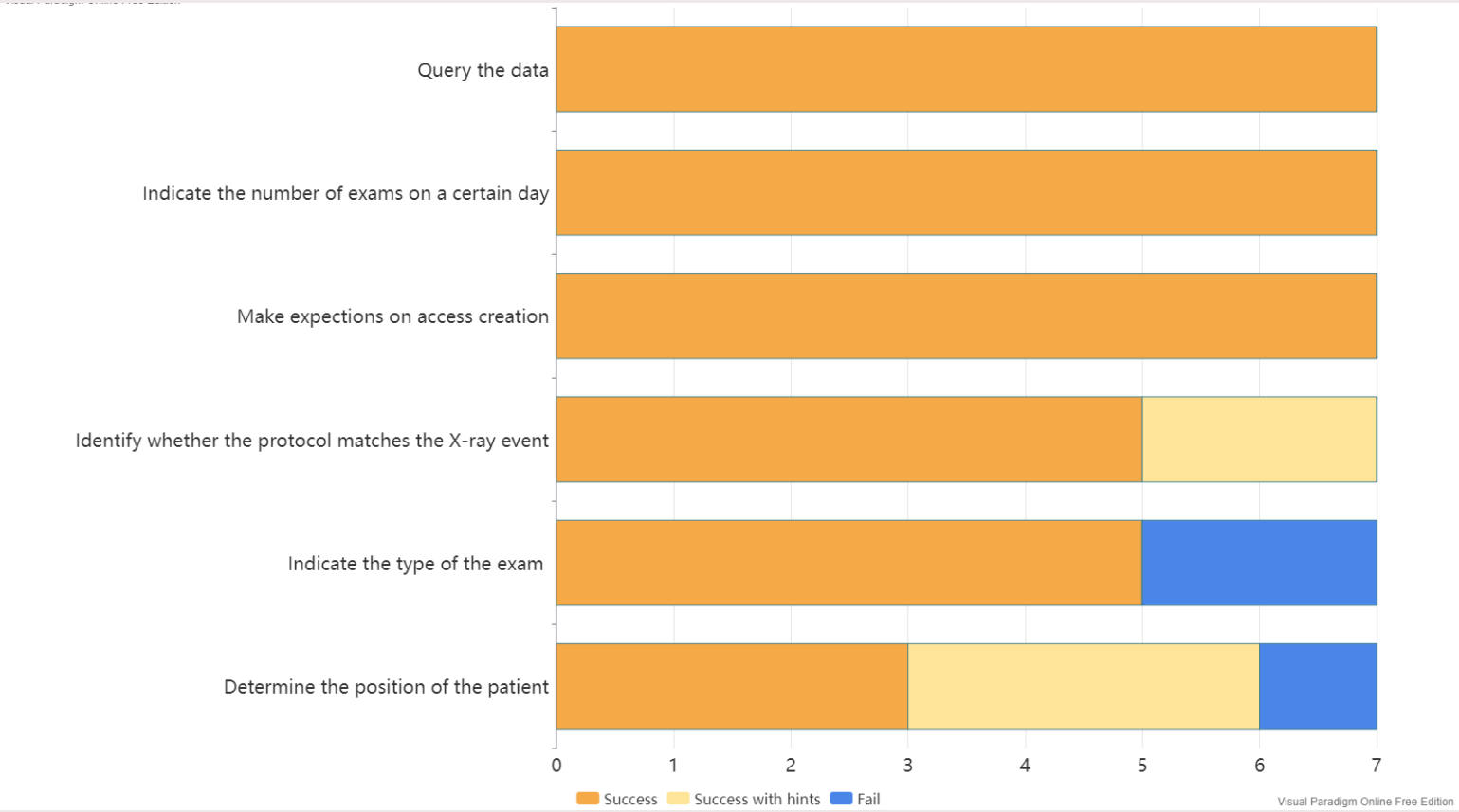


Spatial information

Duration of events

Accurate radiation area

Evaluation: Usefulness – Can users perform the tasks?

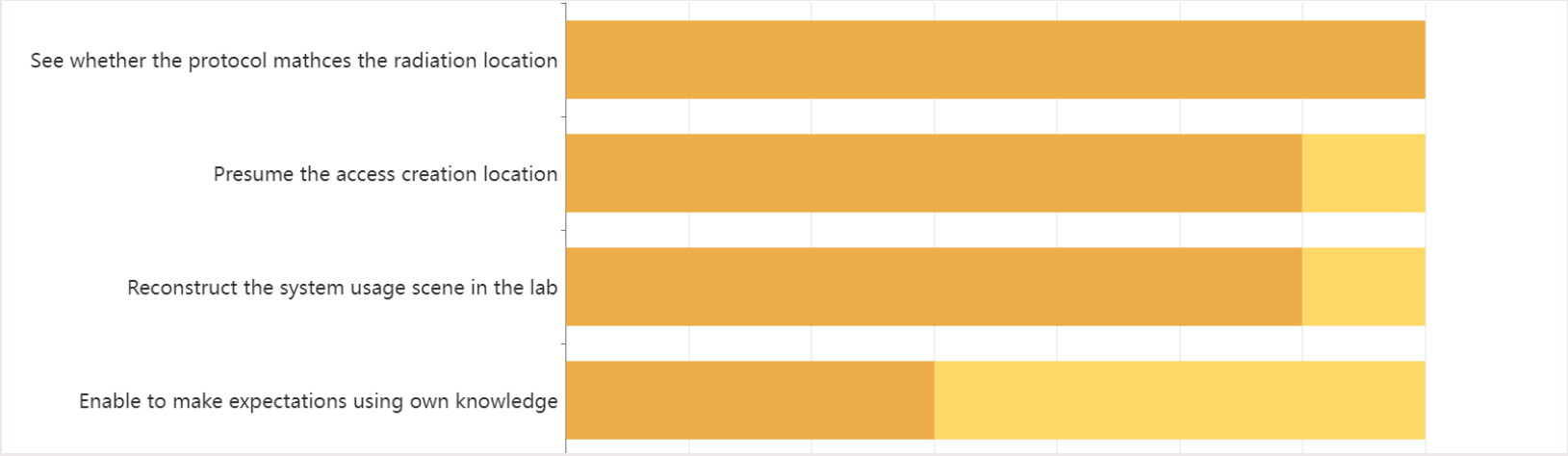


Query data

Make expectations/validations

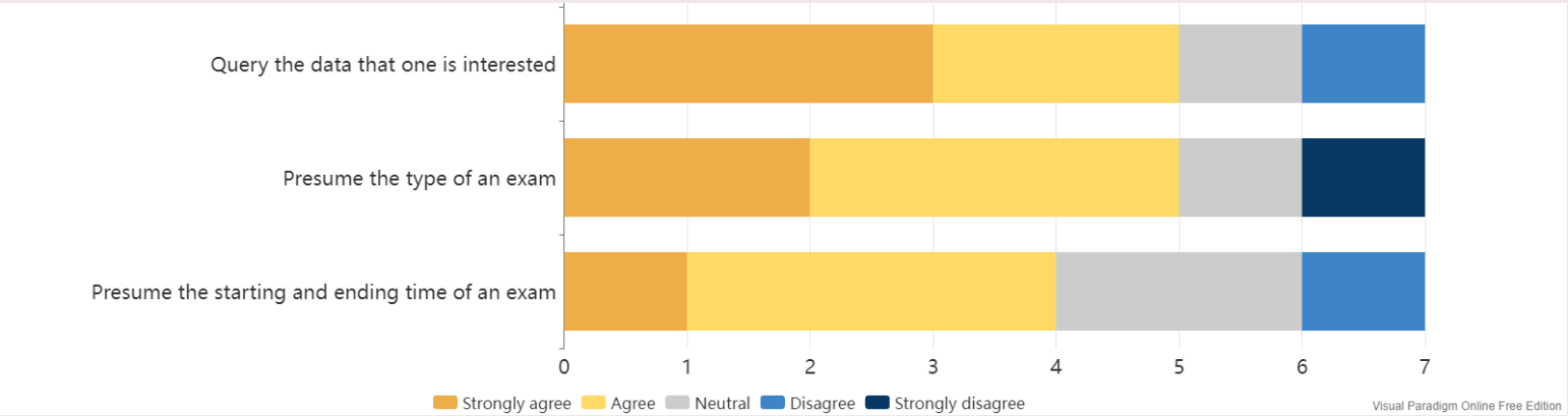
Patient positioning

Evaluation: Ease of use - Does it become easier?



- ☑ Validate EPX protocol
- ☑ Access creation
- ☑ Use scenario reconstruction
- ☑ Bring values

Evaluation: Ease of use - Does it become easier?

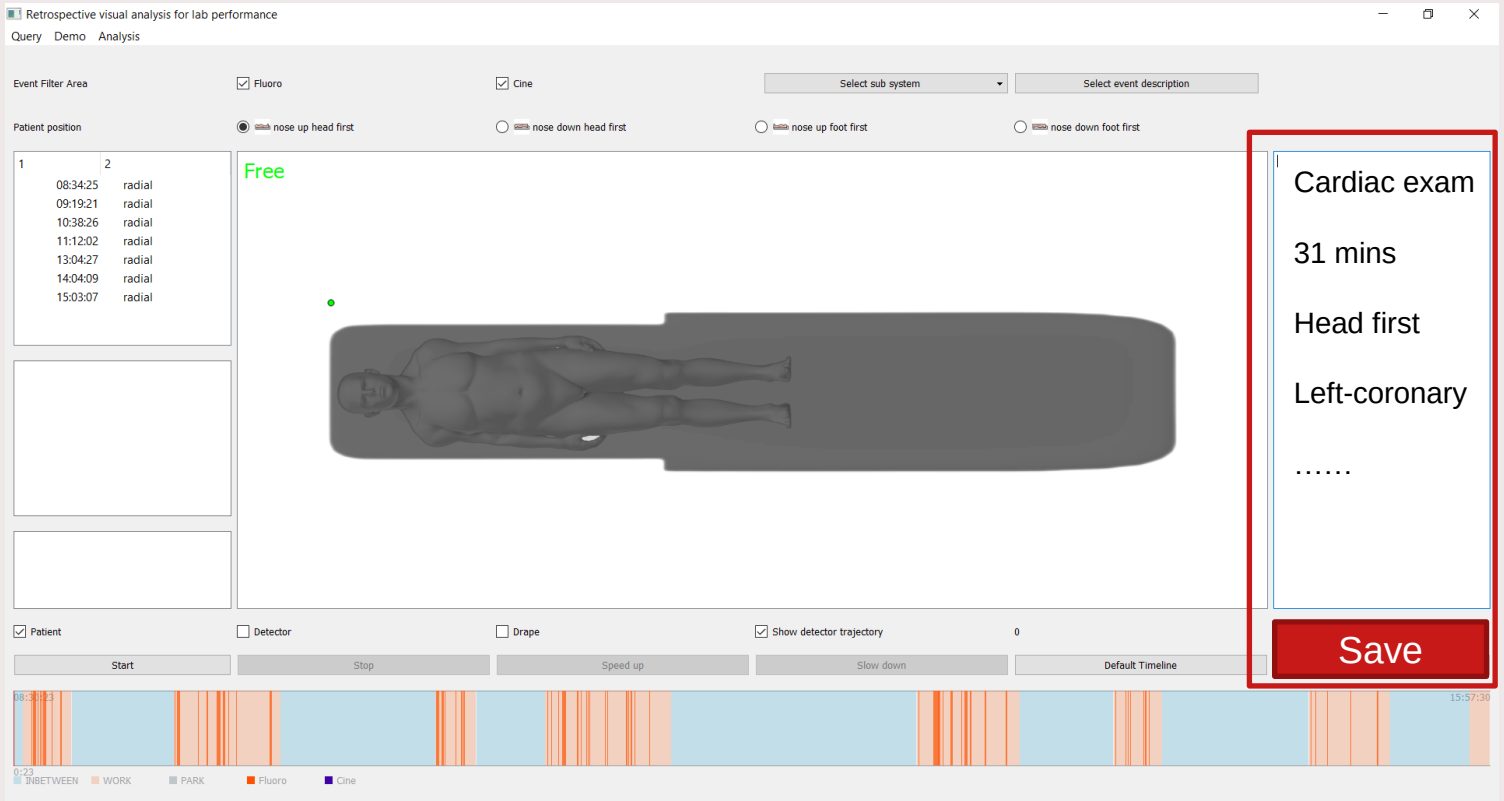


Query data: Easy for experienced Data people, but UI is required for normal user

Type of exam: Protocol select might be wrong

Starting/ending time: **Machine use ≠ Human behavior**

Future work: Annotation area



For each exam:

- Type
- Duration
- Patient positioning
- …

For each X-ray event:

- Radiation area
- Image protocol selection
  - Correct or not
- Dose usage
- …

Future work: Annotation area

For each exam:
- Type
- Duration
- Patient positioning
- …

For each X-ray event:
- Radiation area
- Image protocol selection
  - Correct or not
- Dose usage
- …

Extracted

Dashboard use

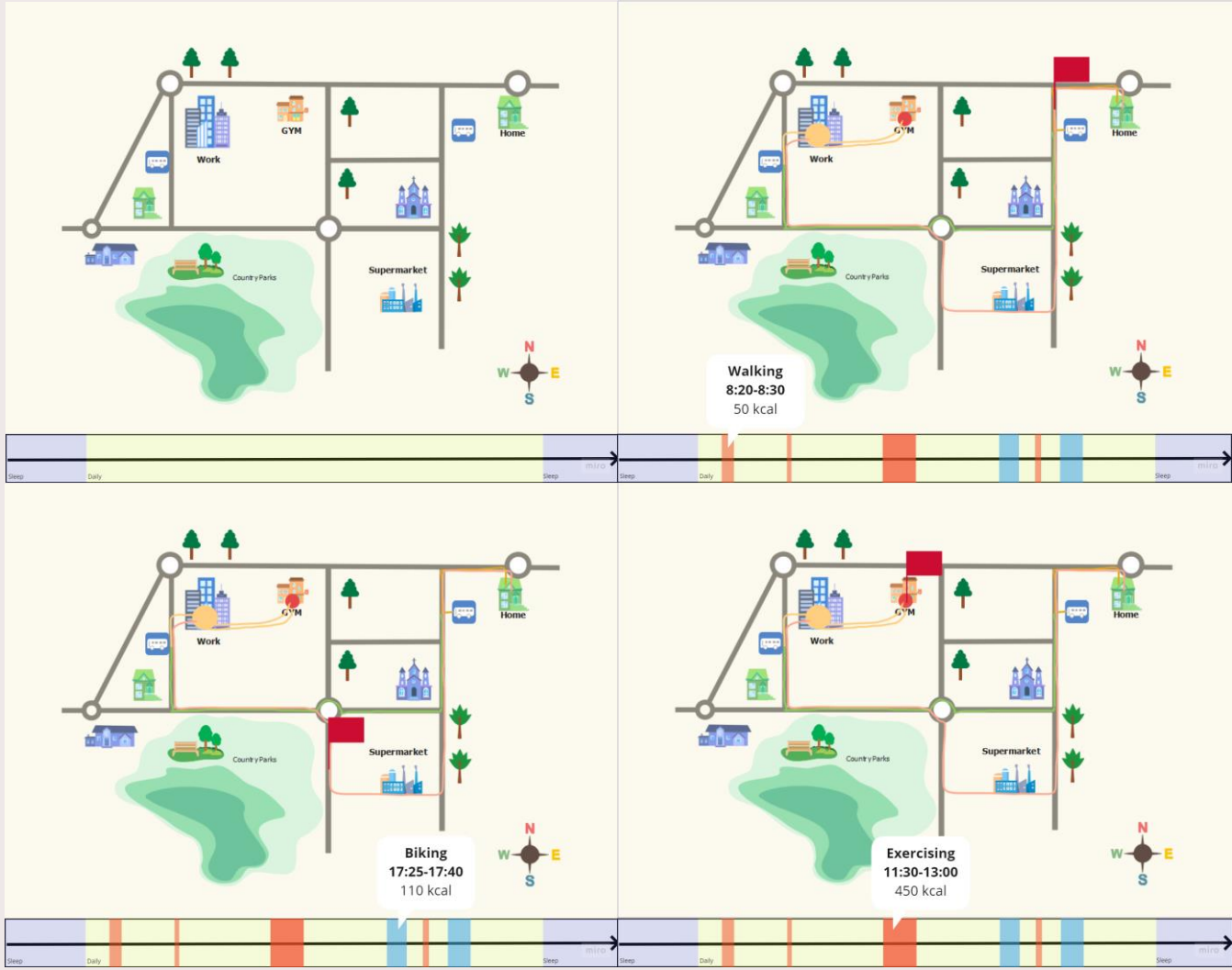
- Ratio of EPX wrongly selected X-ray
- Ratio of over-timed cases
- …

AI training

- Input label for training algorithm on usage log or other data sources

Future work: other domains

- Health tracker(e.g., smartwatch)
- Similar data structure:
  - Daily event with metadata
  - Physical movement based on GPS
- Visualization is required:
  - Personal use
  - Health provider: track patient's daily life
  - Product designer: new functionality



Conclusion

- A data-driven methodology has been proposed to reproduce use scenarios by combining spatial and temporal information from the machine log into one concrete data presentation.
- An interactive application has been developed to do exploratory data analysis and bring out domain knowledge from experts.






Special thanks: To all people who supported

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Questions?