Augmented Intelligence for wearable data analytics

A. BAGGAG – M. AUPETIT

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Public Health issue in Qatar

- **Obesity 45%** of 5-19 y.o. Qataris (2015-2016)

DOI: 10.1016/j.puhe.2018.03.020

- **Type-2 diabetes (reversible) 17%** of Qataris (2019)

DOI: 10.23937/2377-3634/1410099

- **Lack of physical activity and good sleep** are important factors (others: diet)

Objective

- **Exploit wearable data** (e.g., FitBit)
  - to study patients' behaviors to get guidelines
  - to recommend activity patterns
  - to follow up and encourage patients

NPRP11C-0115-180010 Qatar Diabetes Prevention Program

Weill Cornell Medicine-Qatar

مؤسسة حمد الطبية
Hamad Medical Corporation
HEALTH • EDUCATION • RESEARCH صحة • تعليم • بحوث

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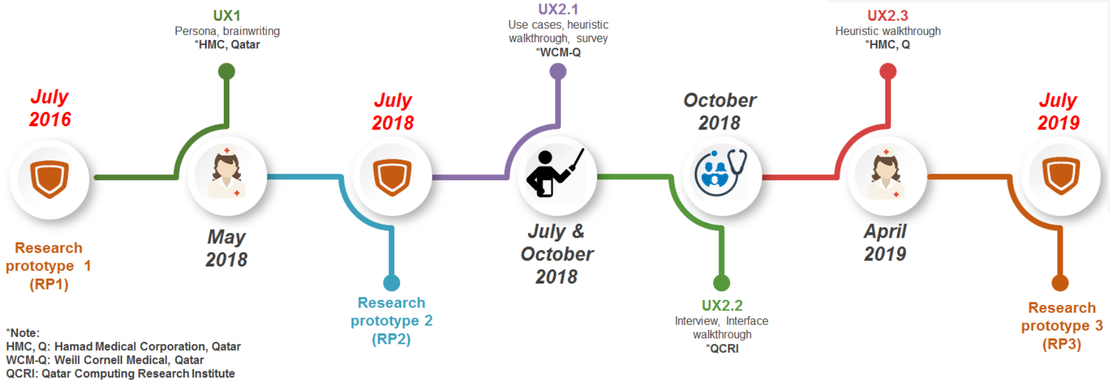


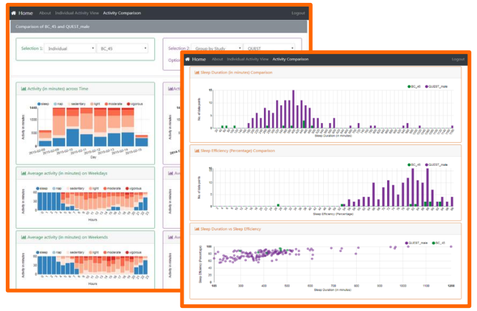
360 Quantified Self

2016 – 2019

Workshops with nurses from **Hamad Medical Corporation**

ActiVis to support nurses

SIHA system to collect data



صحة SIHA

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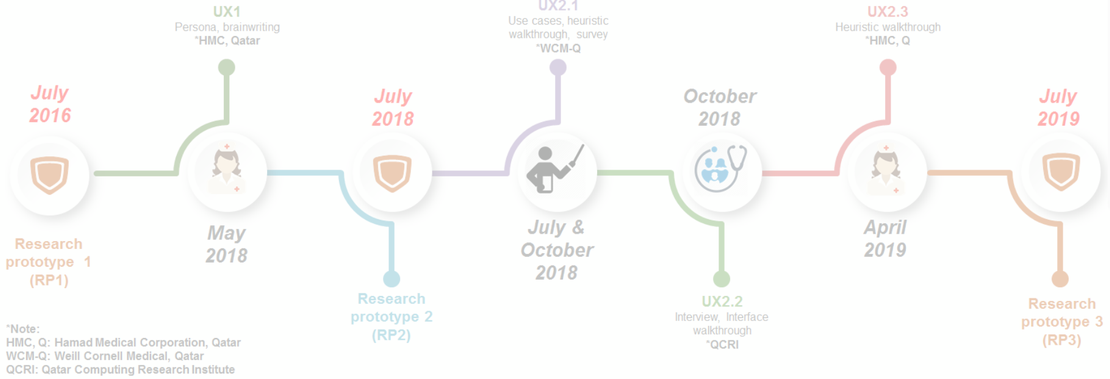

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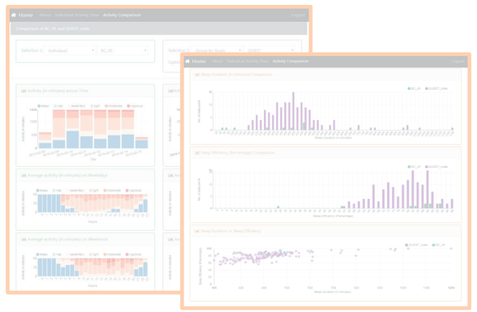

صحة SIHA

Lesson learnt

Use cases and roles for wearable data in clinical settings

- Clinician Researchers study *cohort of patients* and generate treatment guidelines to Doctors
- Doctors treat *single patients* and based on clinician guidelines, prescribe specific treatment for that patient
- Nurses monitor *single patients* for following their treatment prescribed by Doctors

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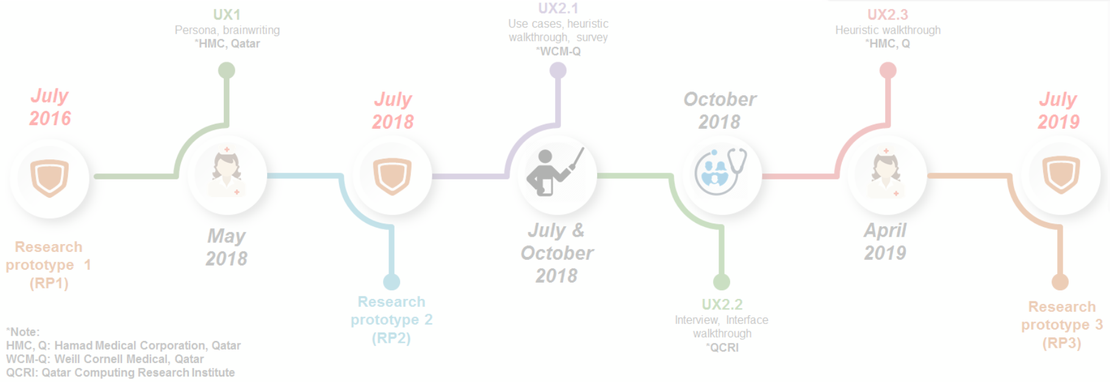

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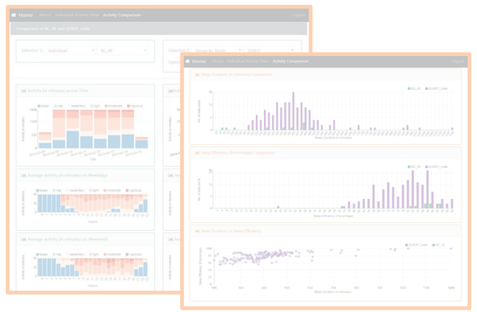

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- Nurses monitor *single patients* for following their treatment prescribed by Doctors

Nothing can happen in the clinic without Clinician Researcher first emitting guidelines, that Doctors can adapt to prescribe treatments to a specific Patient, then that Nurses can monitor

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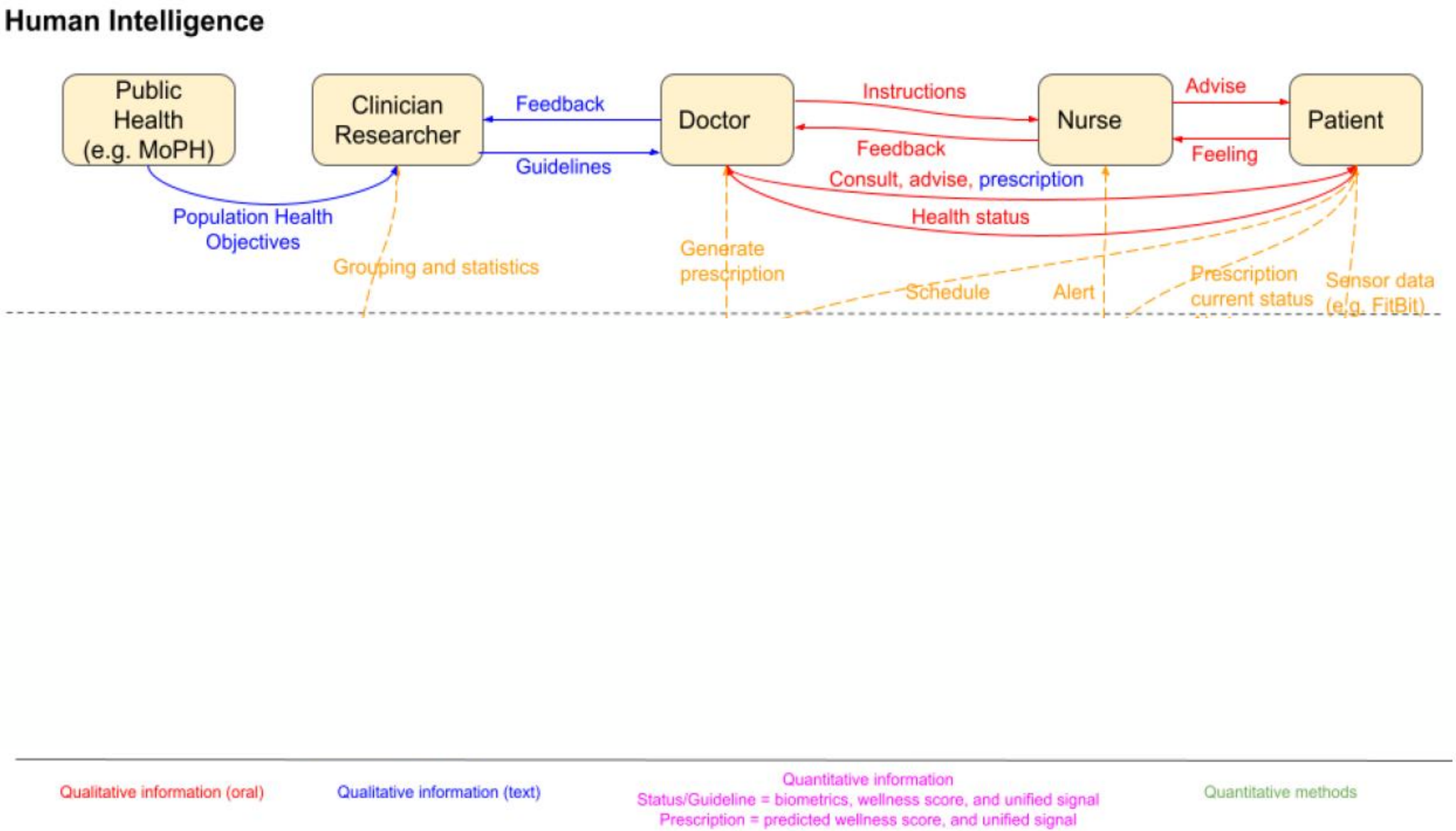

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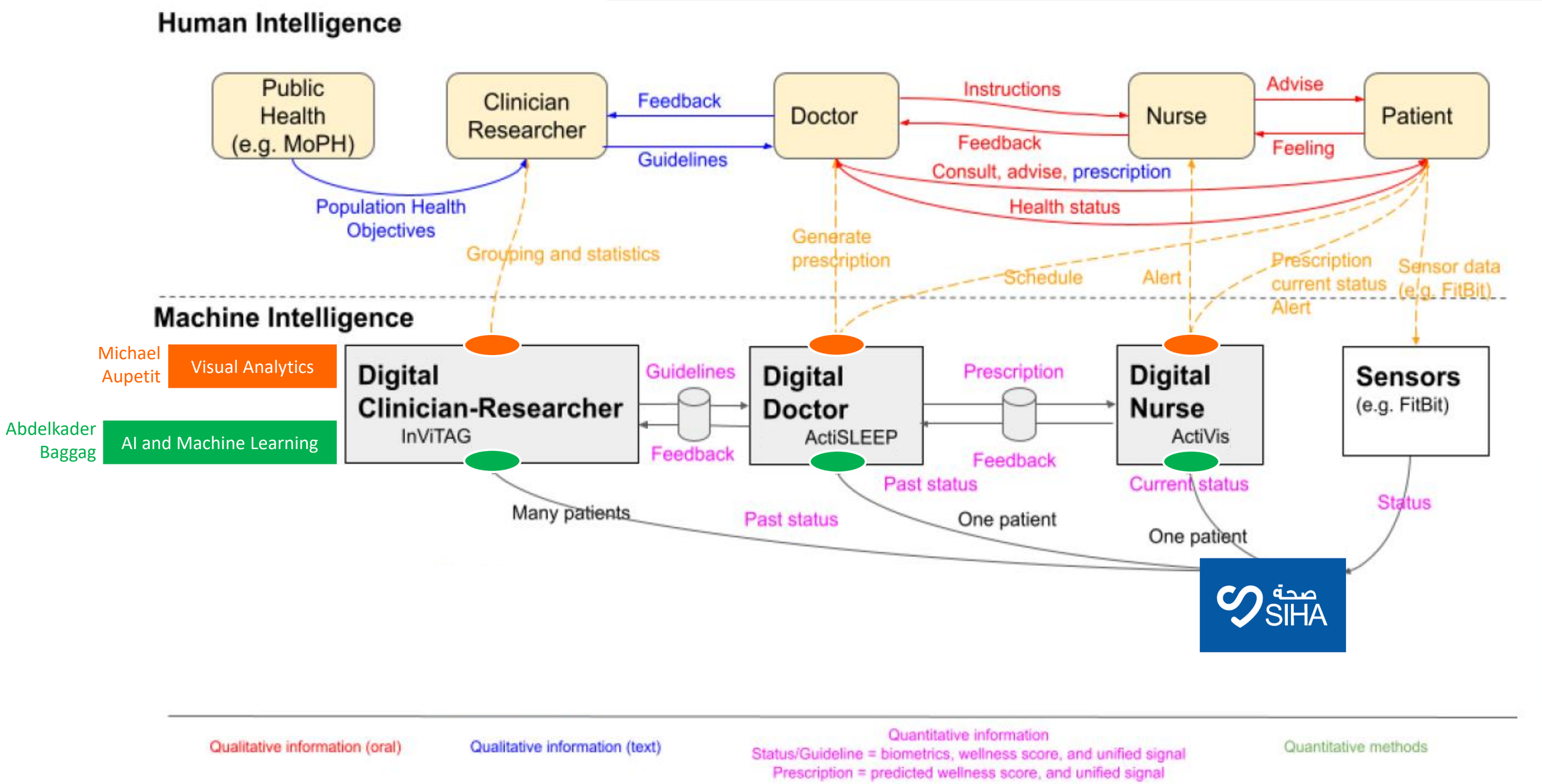

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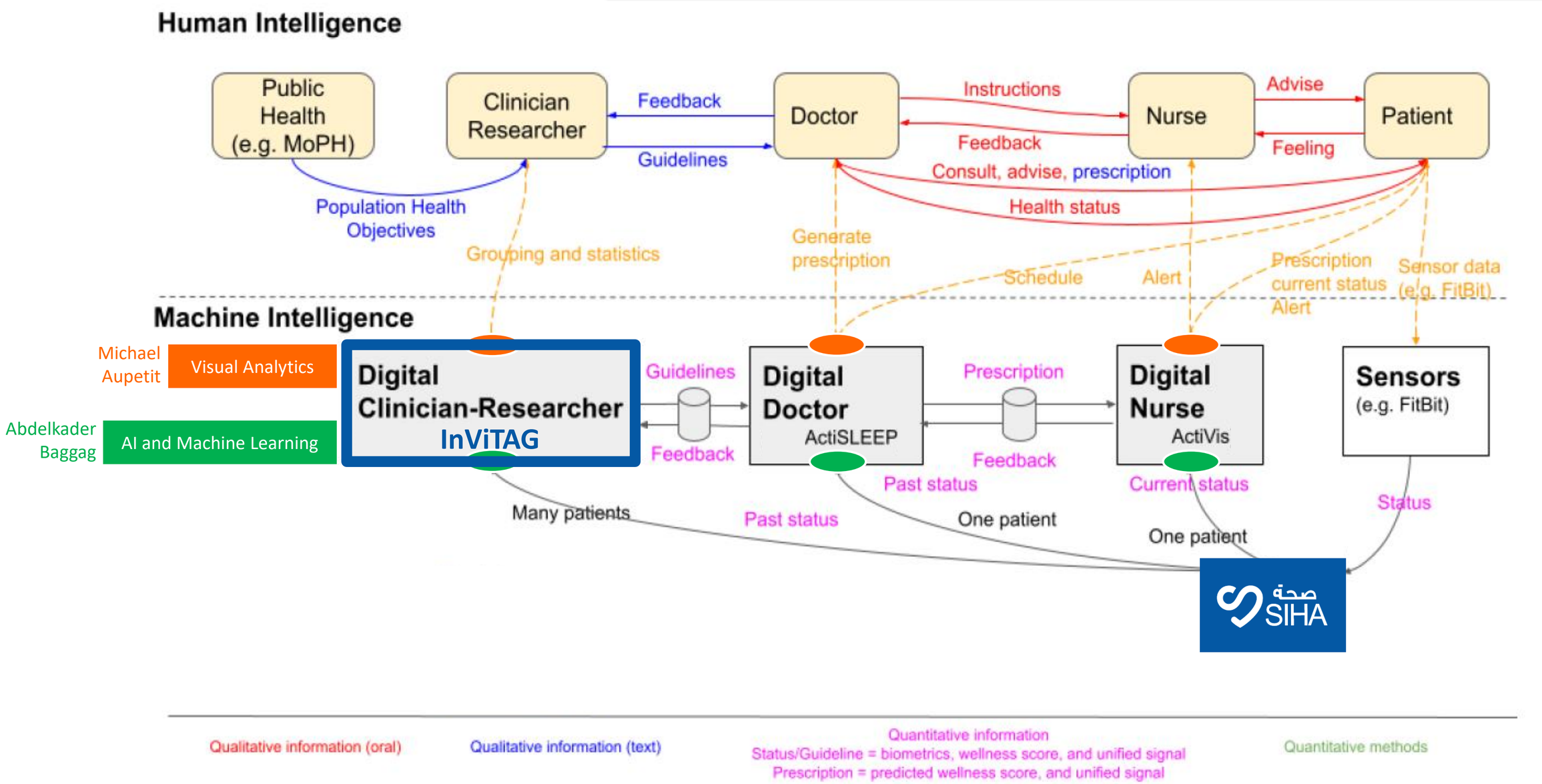

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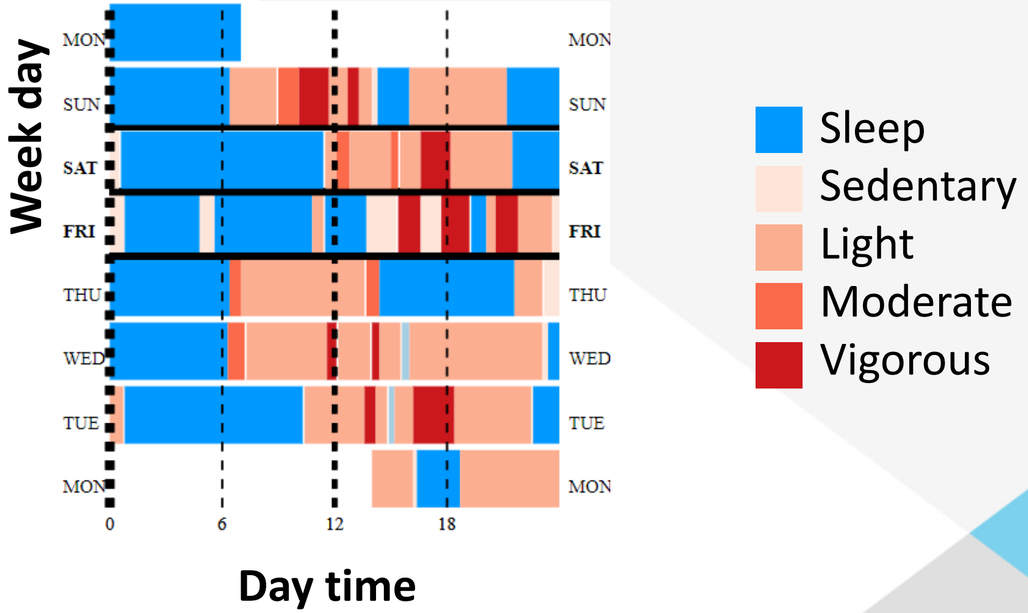
Wearable data

1 file per patient

tart_time	end_time	activity_level
2/9/2015 14:00	2/9/2015 17:12	light
2/9/2015 17:13	2/9/2015 18:12	light
2/9/2015 18:13	2/9/2015 20:07	light
2/9/2015 20:08	2/9/2015 20:17	sedentary
2/9/2015 20:18	2/10/2015 5:48	sleep
2/10/2015 5:49	2/10/2015 7:20	sedentary
2/10/2015 7:21	2/10/2015 8:55	light
2/10/2015 8:56	2/10/2015 10:15	moderate
2/10/2015 10:16	2/10/2015 11:04	light
2/10/2015 11:05	2/10/2015 13:34	light
2/10/2015 13:35	2/10/2015 15:45	light
2/10/2015 15:46	2/10/2015 16:41	vigorous
2/10/2015 16:42	2/10/2015 17:11	moderate
2/10/2015 17:12	2/10/2015 17:51	sedentary
2/10/2015 17:52	2/10/2015 18:28	moderate
2/10/2015 18:29	2/10/2015 19:10	vigorous
2/10/2015 19:11	2/10/2015 21:24	light
2/10/2015 21:25	2/10/2015 22:15	light
2/10/2015 22:16	2/11/2015 0:22	sedentary
2/11/2015 0:23	2/11/2015 4:27	sleep
2/11/2015 4:28	2/11/2015 5:09	moderate
2/11/2015 5:10	2/11/2015 6:25	light

1 image per patient



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Wearable data

1000s patients

start_time	end_time	activity_level
2/9/2015 14:00	2/9/2015 17:12	light
2/9/2015 17:13	2/9/2015 18:12	light
2/9/2015 18:13	2/9/2015 20:07	light
2/9/2015 20:08	2/9/2015 20:17	sedentary
2/9/2015 20:18	2/10/2015 5:48	sleep
2/10/2015 5:49	2/10/2015 7:20	sedentary
2/10/2015 7:21	2/10/2015 8:55	light
2/10/2015 8:56	2/10/2015 10:15	moderate
2/10/2015 10:16	2/10/2015 11:04	light
2/10/2015 11:05	2/10/2015 13:34	light
2/10/2015 13:35	2/10/2015 15:45	light
2/10/2015 15:46	2/10/2015 16:41	vigorous
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2/10/2015 17:12	2/10/2015 17:51	sedentary
2/10/2015 17:52	2/10/2015 18:28	moderate
2/10/2015 18:29	2/10/2015 19:10	vigorous
2/10/2015 19:11	2/10/2015 21:24	light
2/10/2015 21:25	2/10/2015 22:15	light
2/10/2015 22:16	2/11/2015 0:22	sedentary
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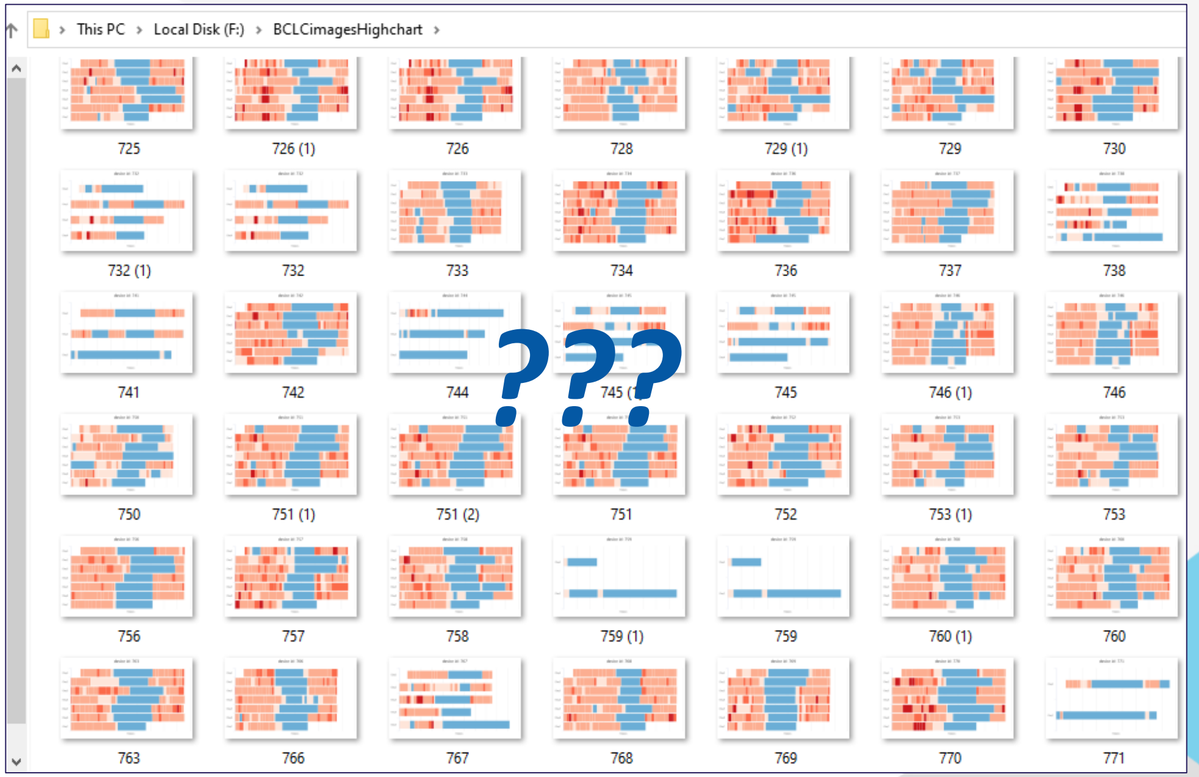

Objective: support the Clinician-Researcher
to explore and analyze 1000s of patient data (cohort studies)

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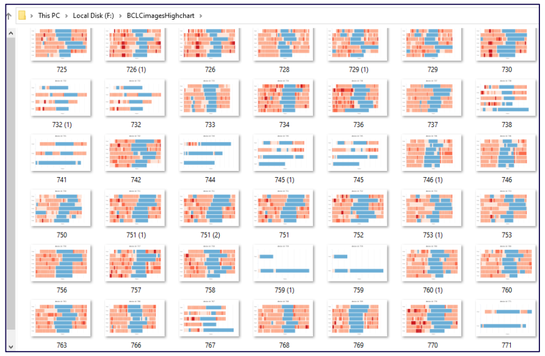
1000s of patient data

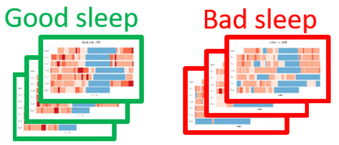


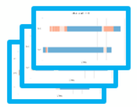
Grouping

Knowledge-building

Feature space analysis

Link with external knowledge





Low quality data

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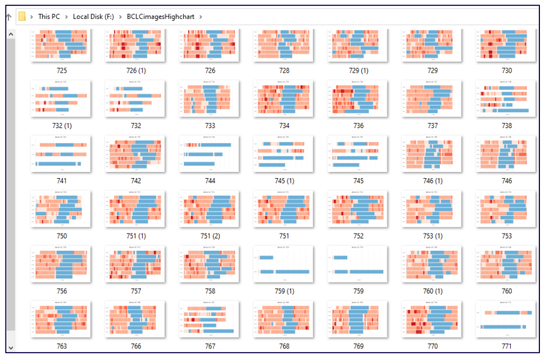
1000s of patient data



Grouping

Knowledge-building

Feature space analysis

Link with external knowledge

Good sleep

Bad sleep

Low quality data

Statistical Analysis

Patients typology

Guidelines for Doctors

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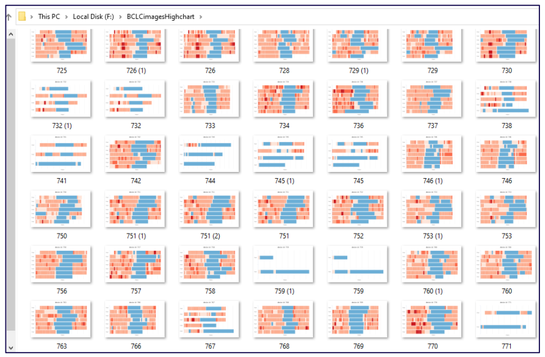
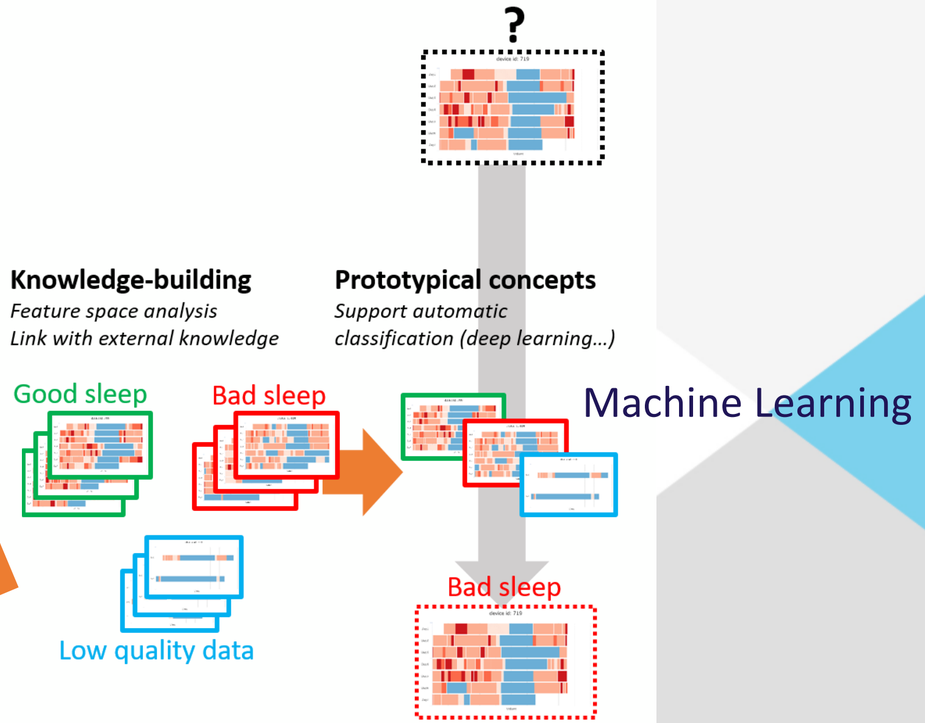


Grouping

Statistical Analysis
Patients typology
Guidelines for Doctors

Standard supervised pipeline
Use categories to classify new data



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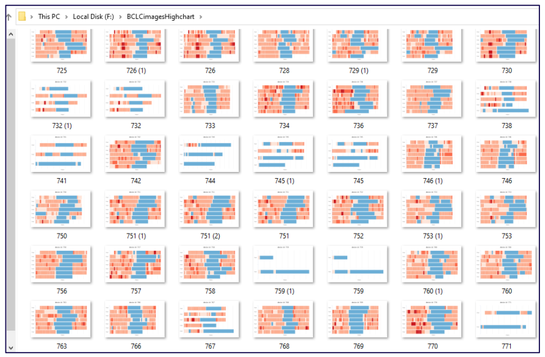
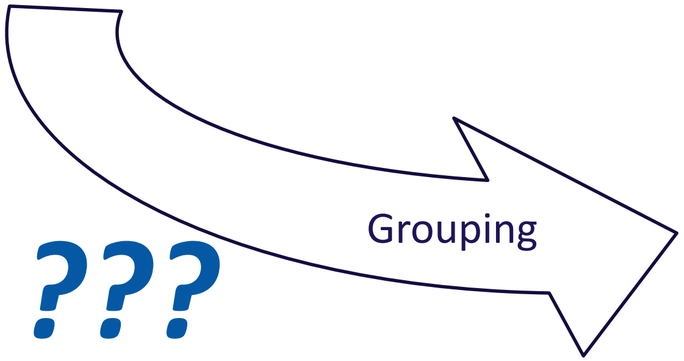


InViTAG challenges

- **Exploratory analysis**
- **Unexpected patterns**
- **Automation is difficult**



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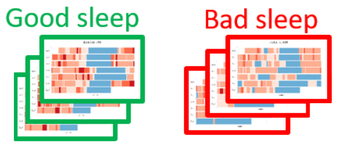

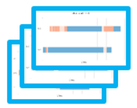

Low quality data

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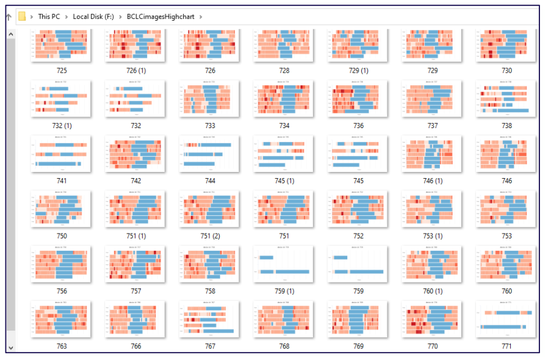

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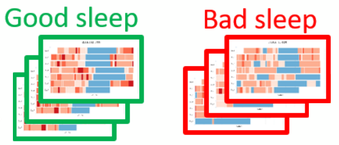

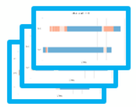

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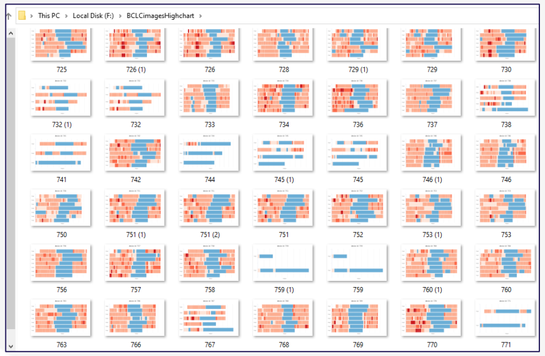
InViTAG tasks to support

- **Arranging and ordering** yet unknown objects
- **Creating categories** for these objects
- **Naming** these categories
- Do that **interactively** and **at scale**



Visual metaphors

Areas

Piles

Boxes

Clusters

D. KIRSH The intelligent use of space. Artificial Intelligence 73, 1 (1995), 31–68.

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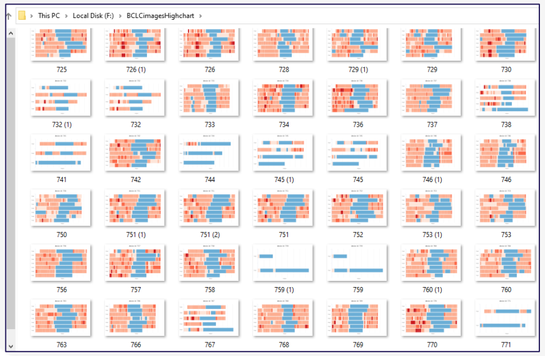

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Visual metaphors

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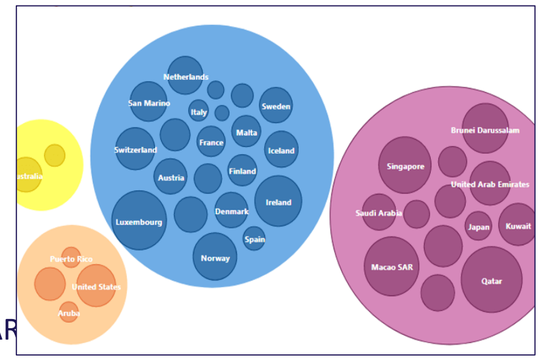
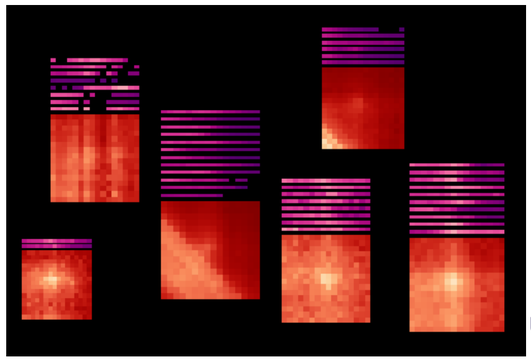
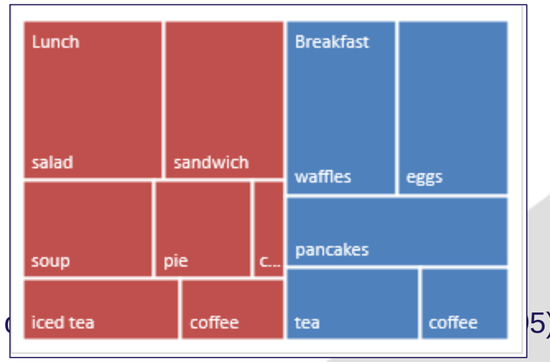


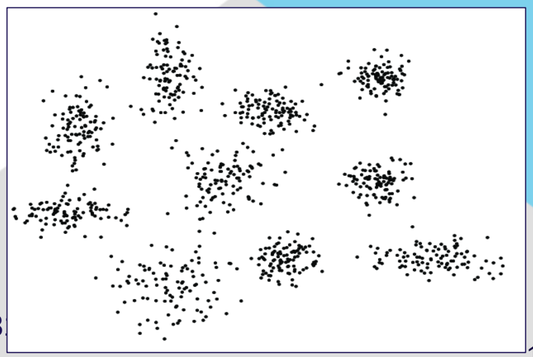
Piles



Boxes



Clusters



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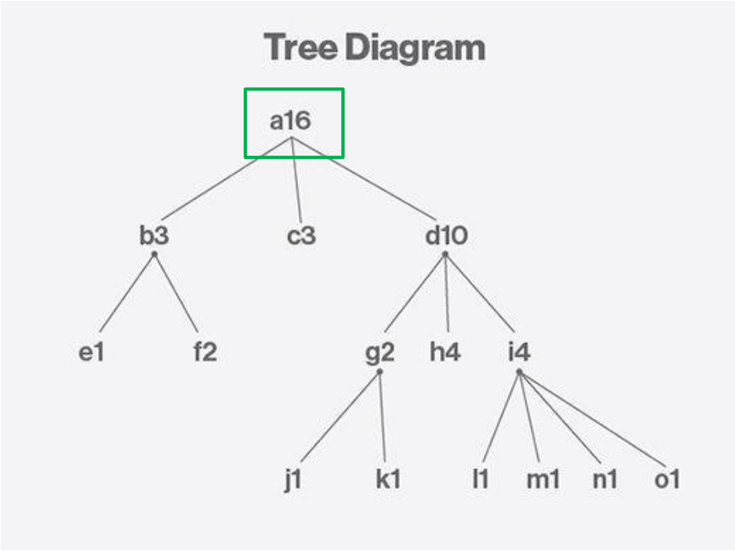
InViTAG research output

- **Interactive** Voronoi Treemap
- **Scalable** based on visualization and machine learning

What is a Treemap?



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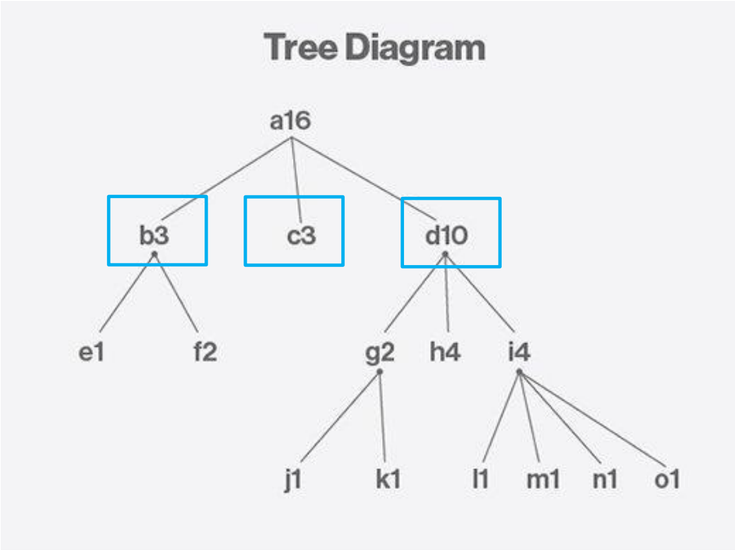

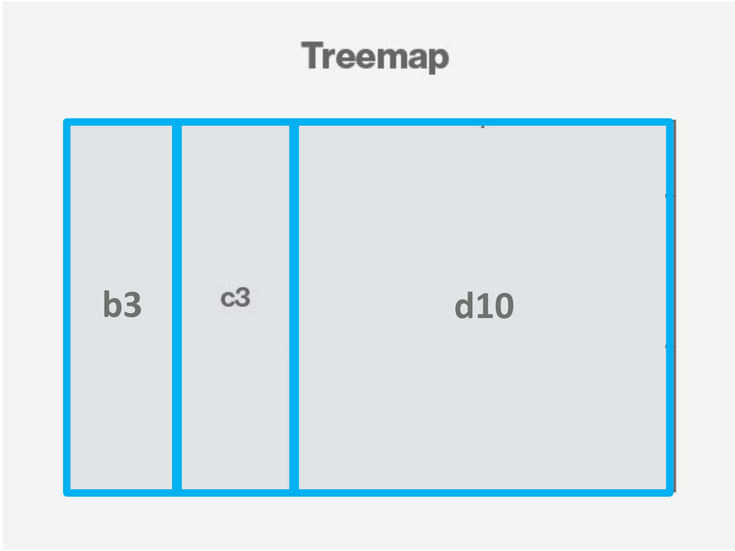

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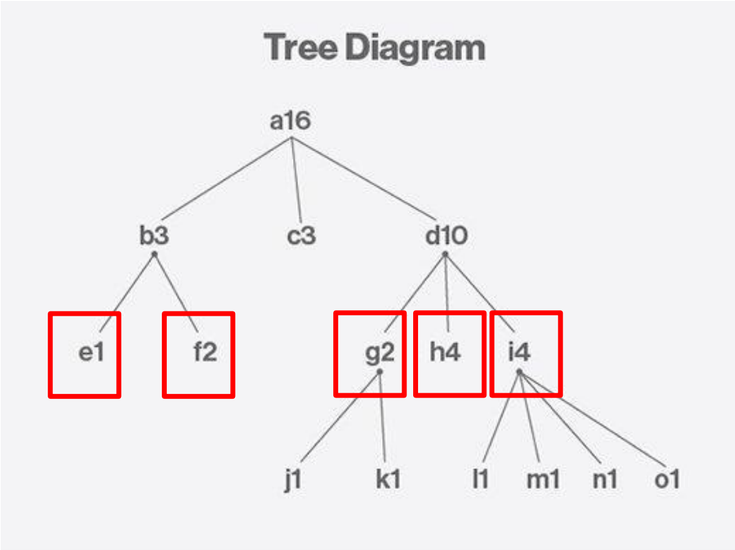

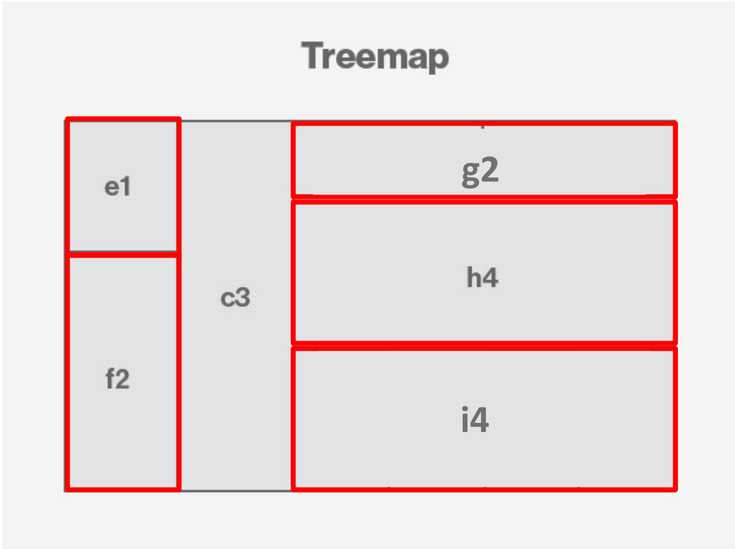

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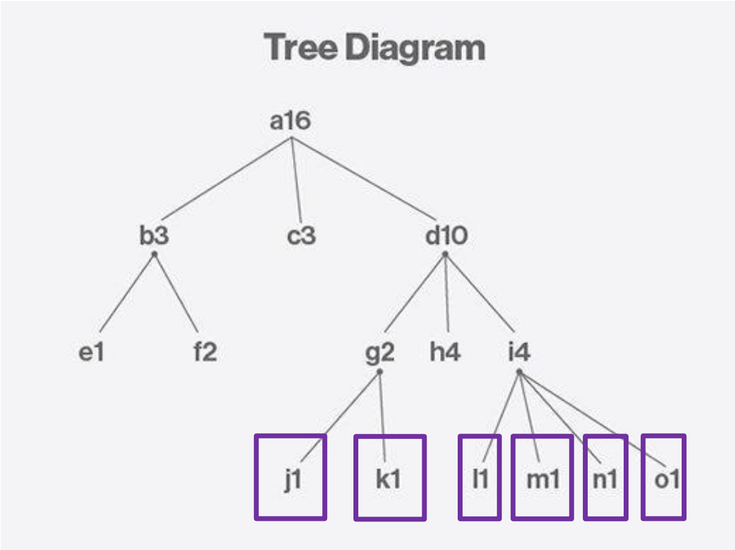

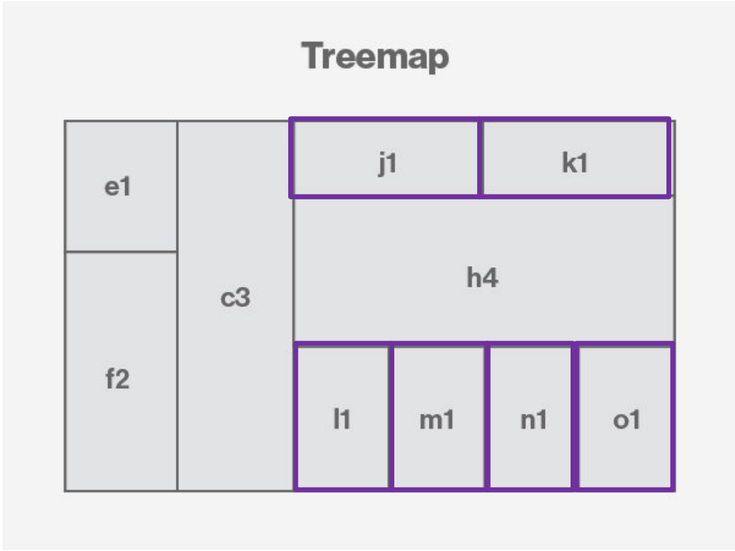

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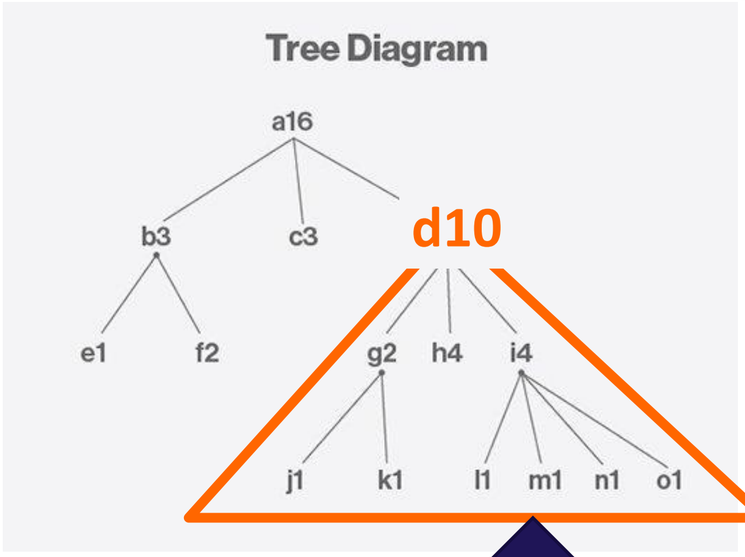
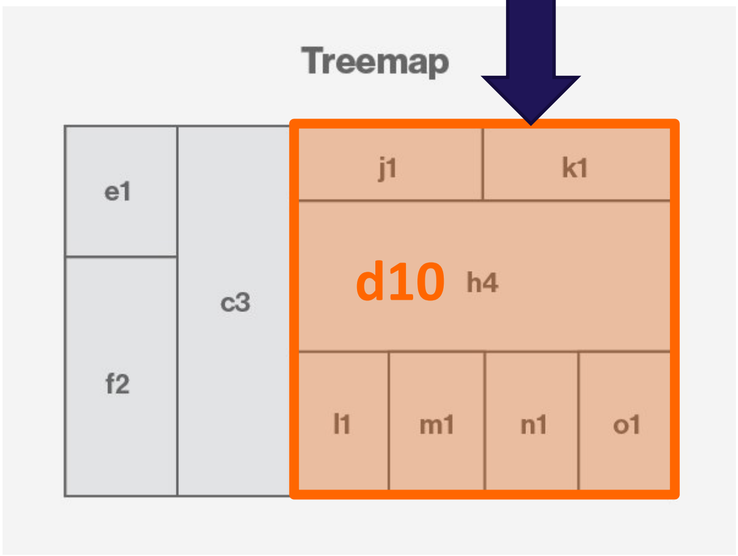
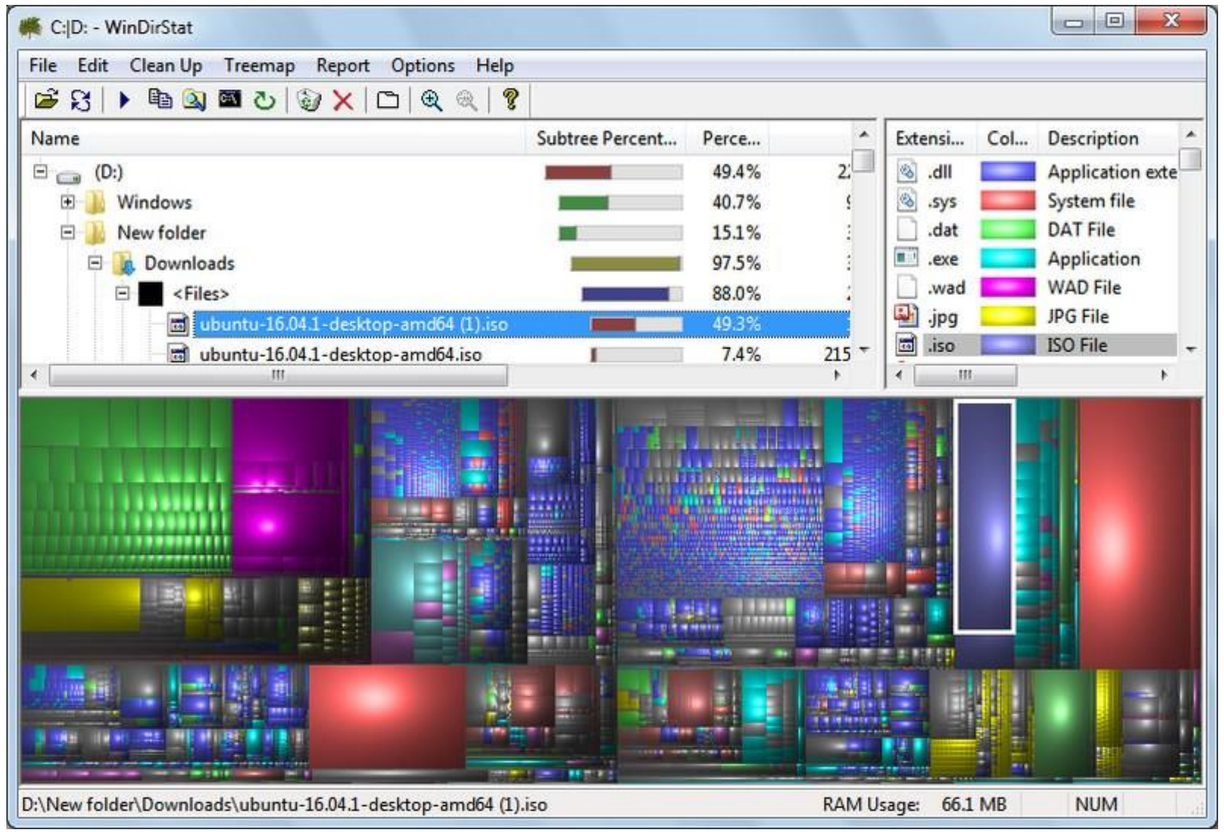


Area proportional to nodes weight/size



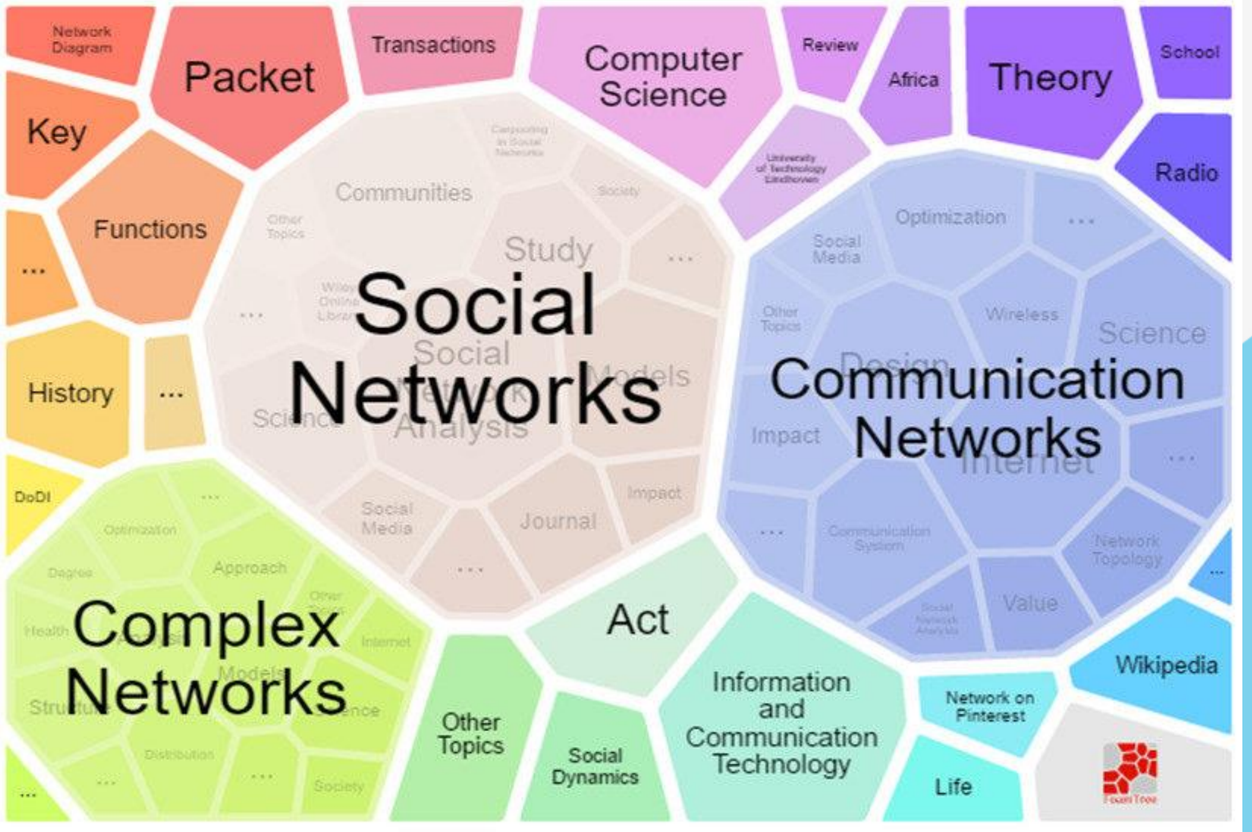
What is a Treemap?

Squarified treemap



WinDirStat to visualize disk space

Voronoi treemap



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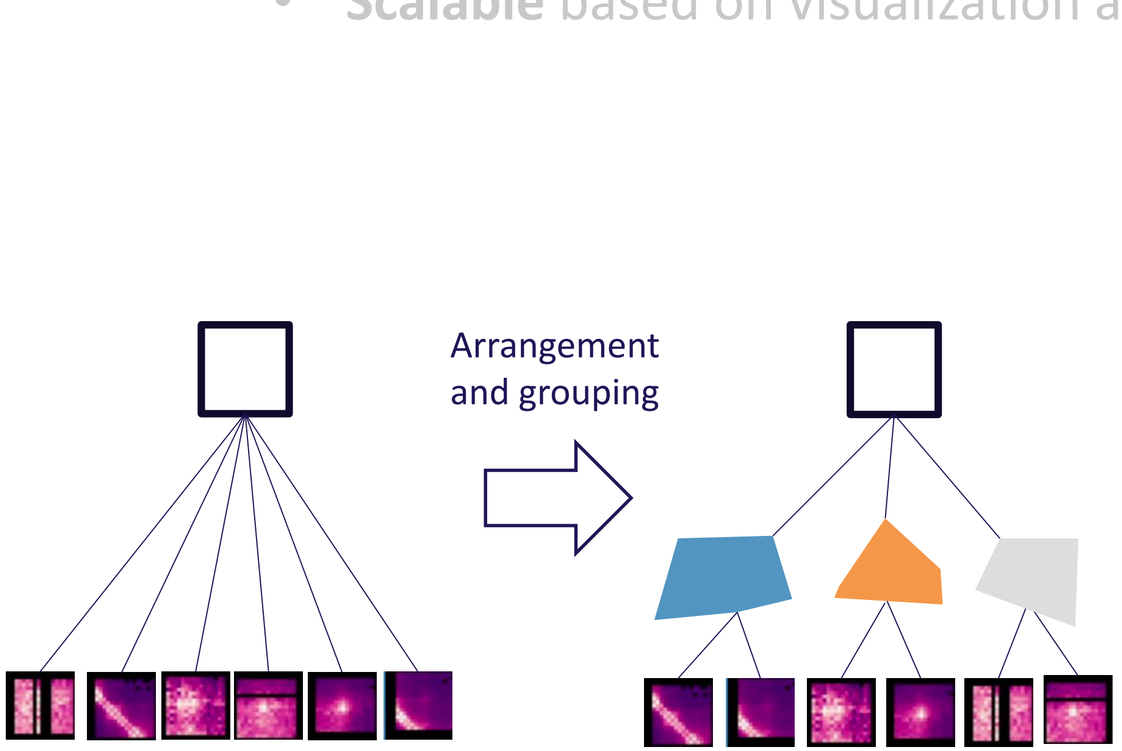

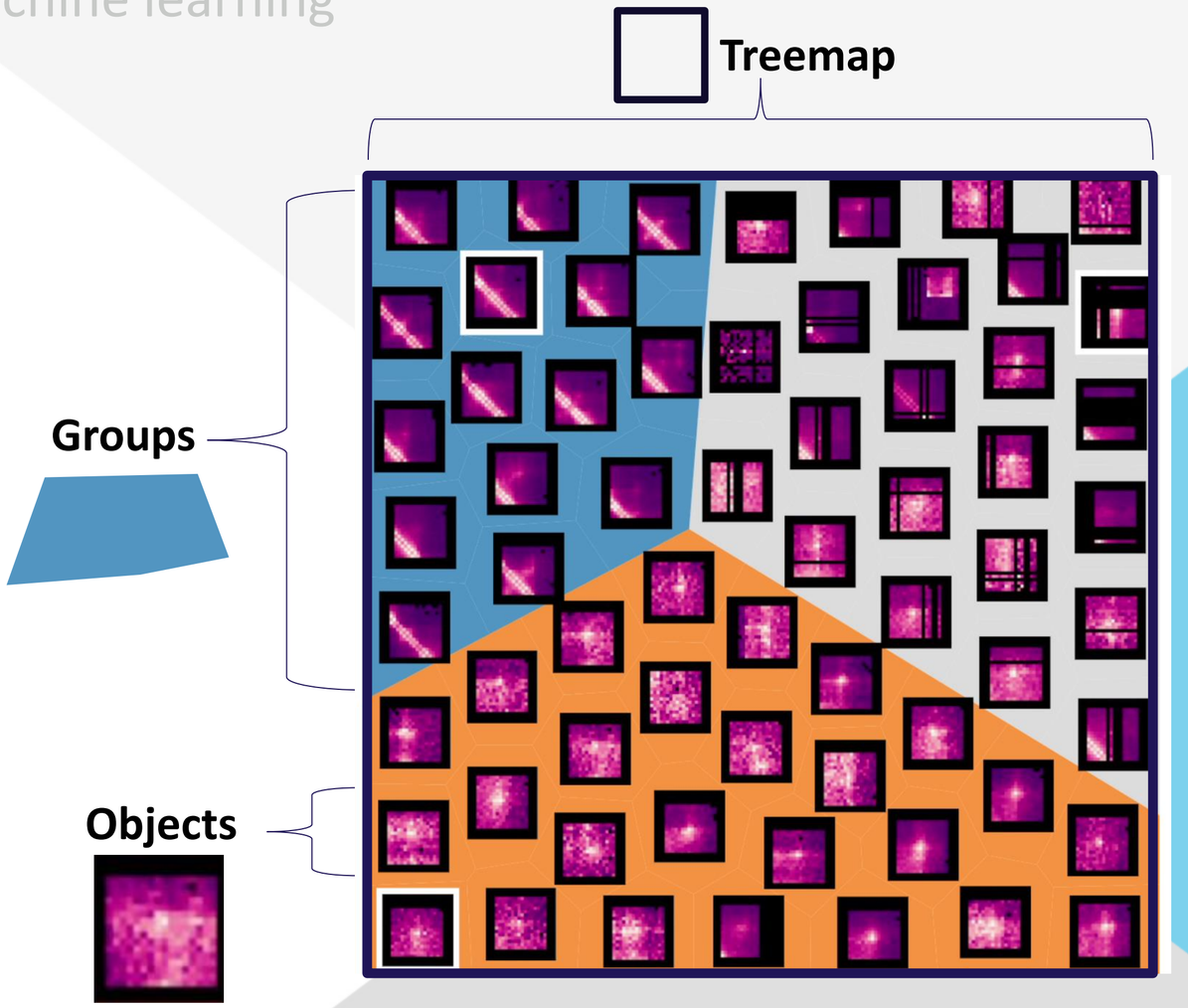

Augmented Intelligence for wearable data analytics

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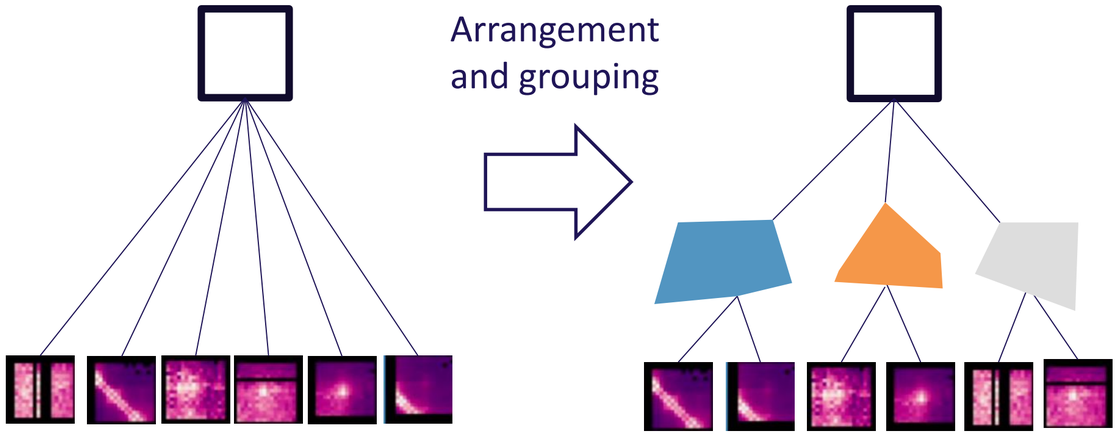
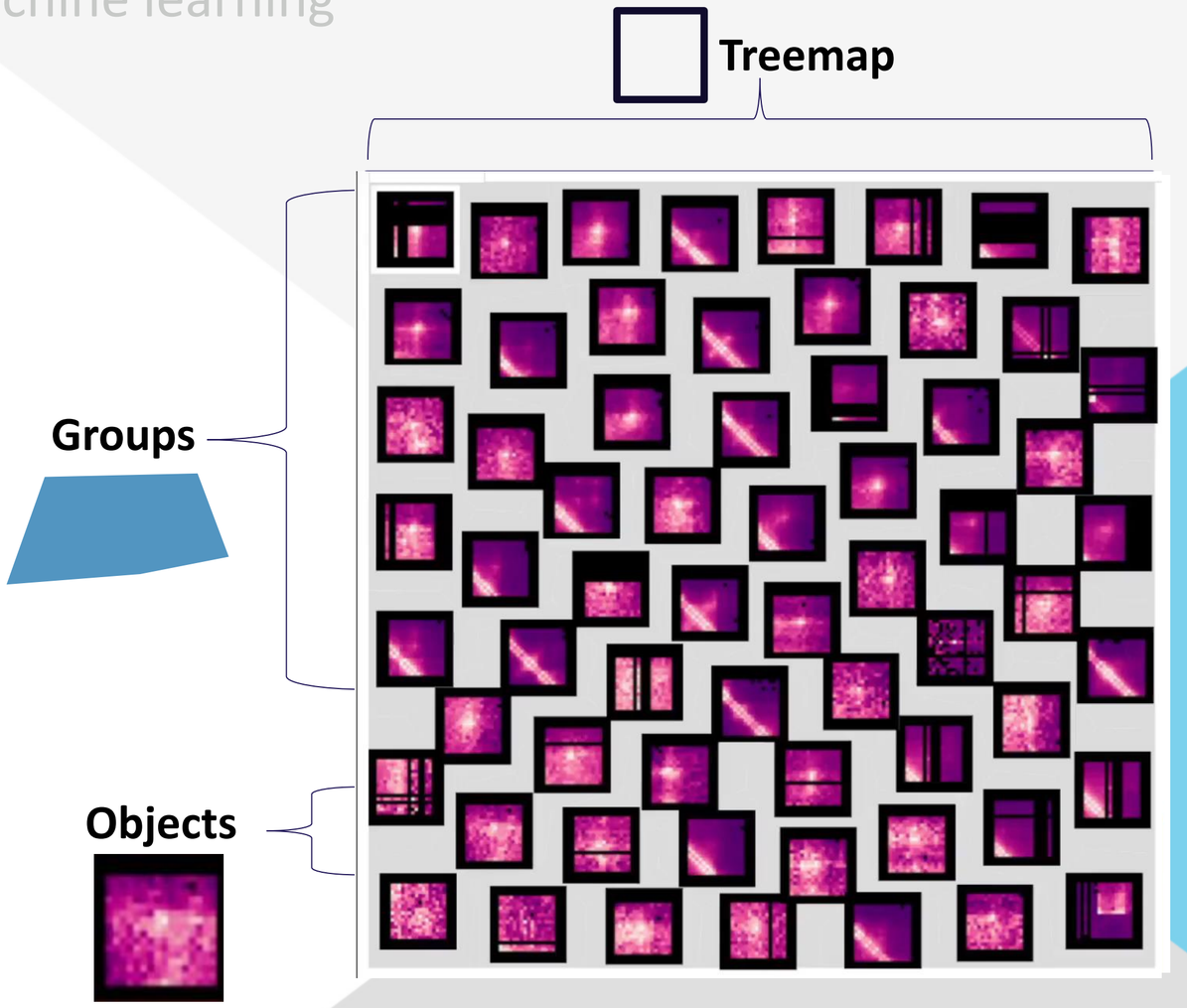
InViTAG research output

- **Interactive** Voronoi Treemap
- **Scalable** based on visualization and machine learning





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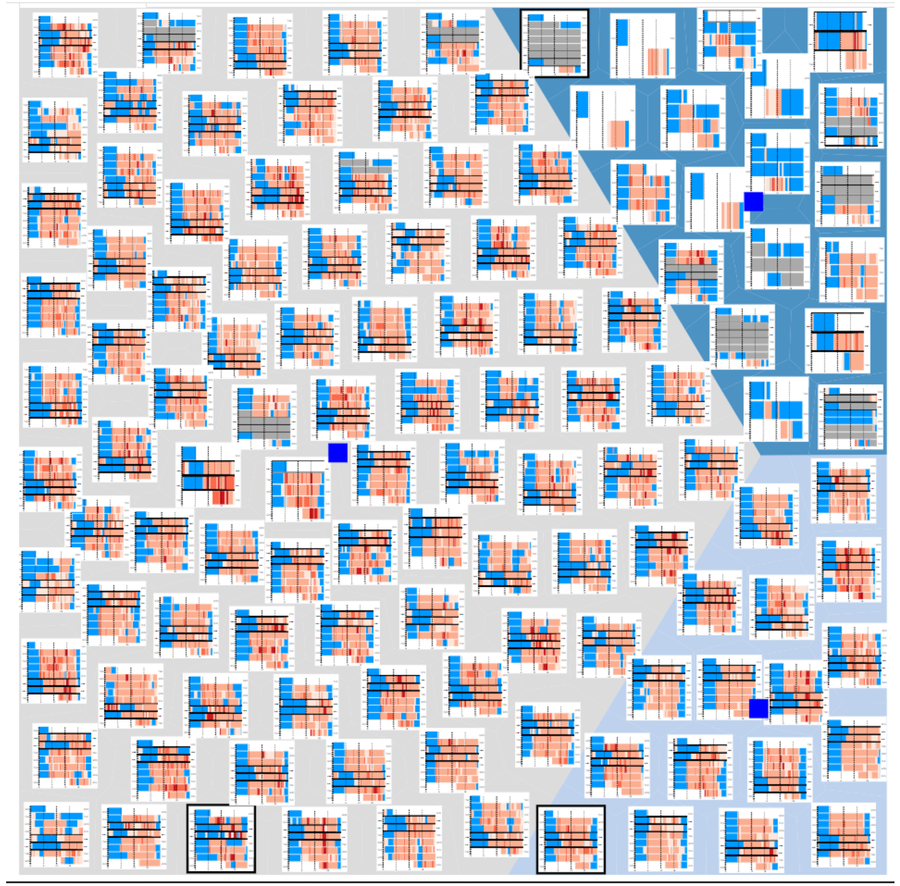
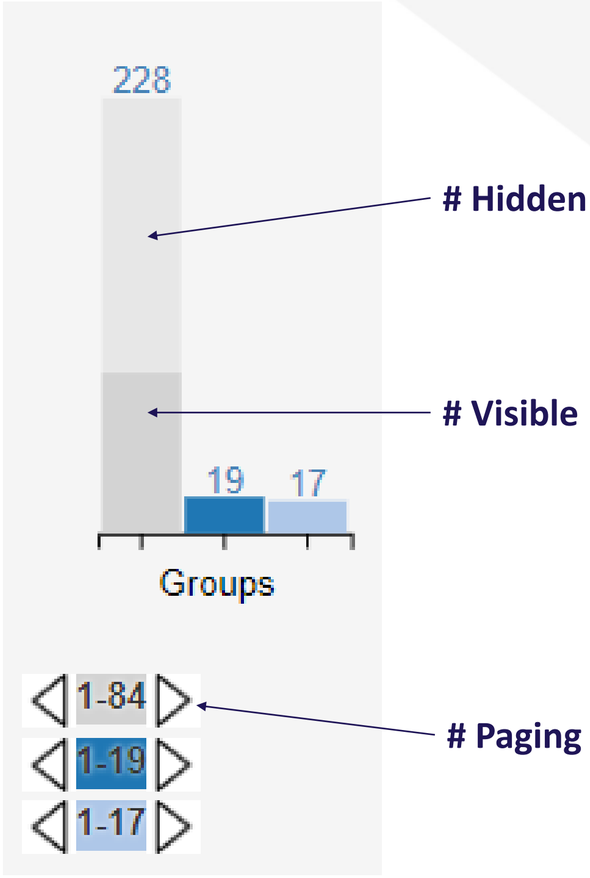


Graphical features



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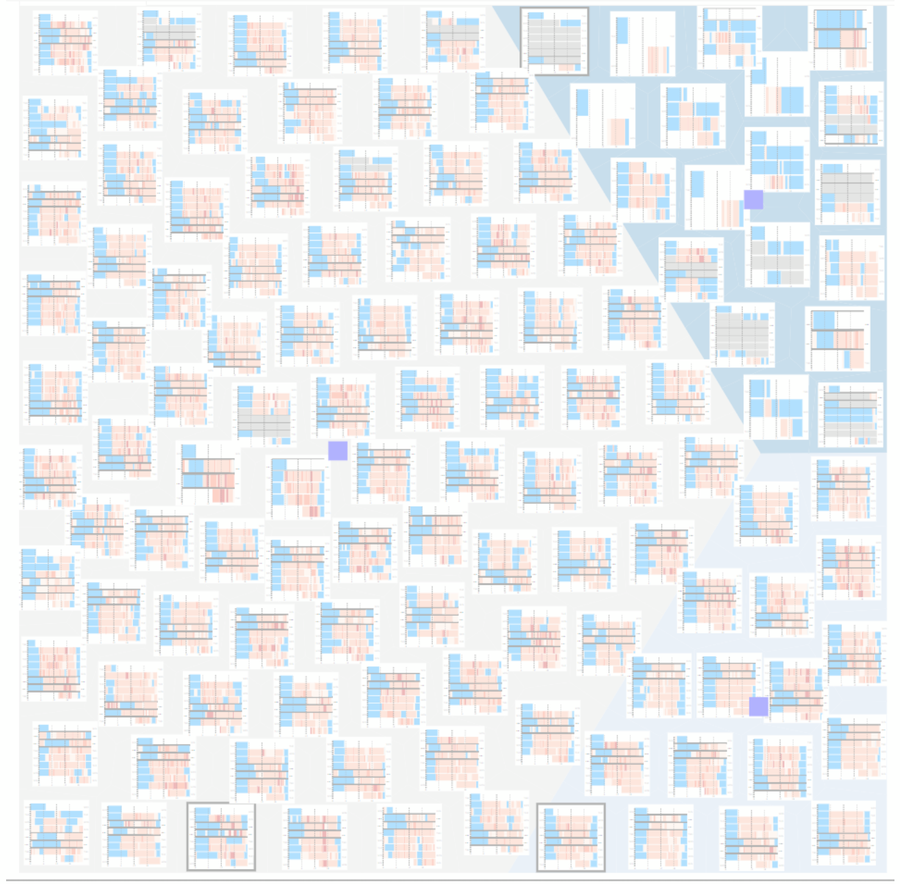
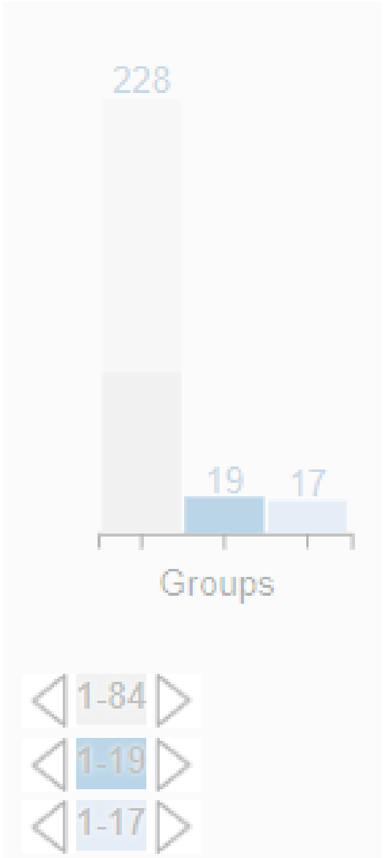
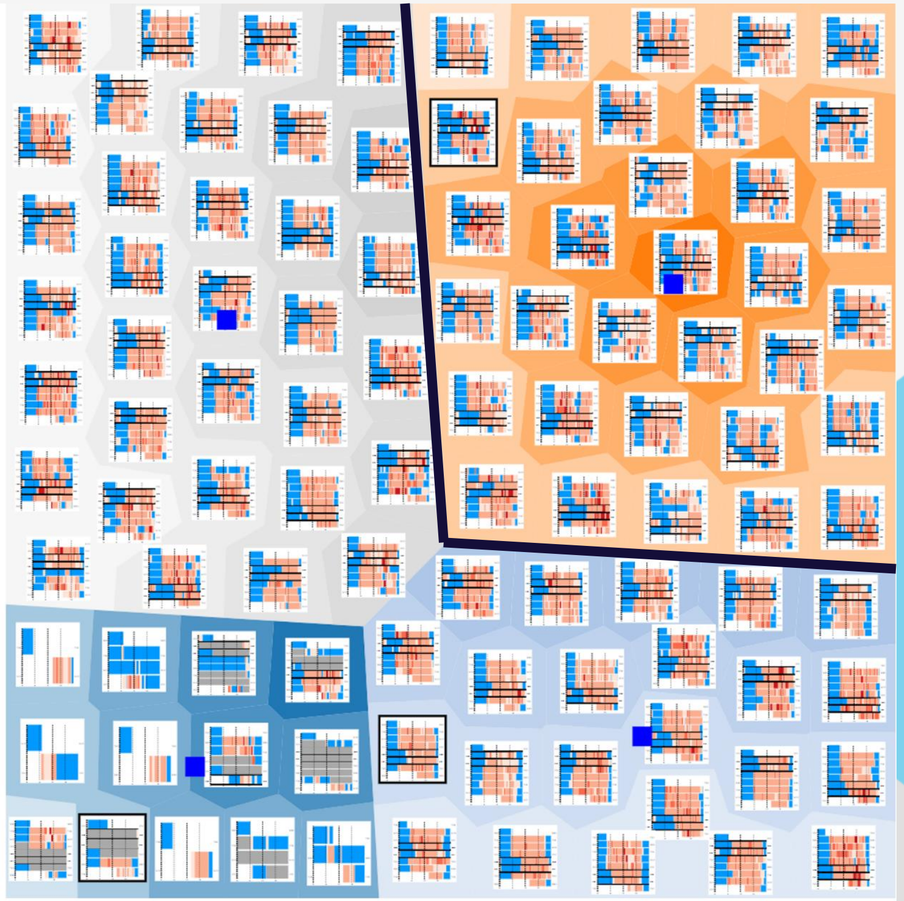




Graphical + Machine Learning features



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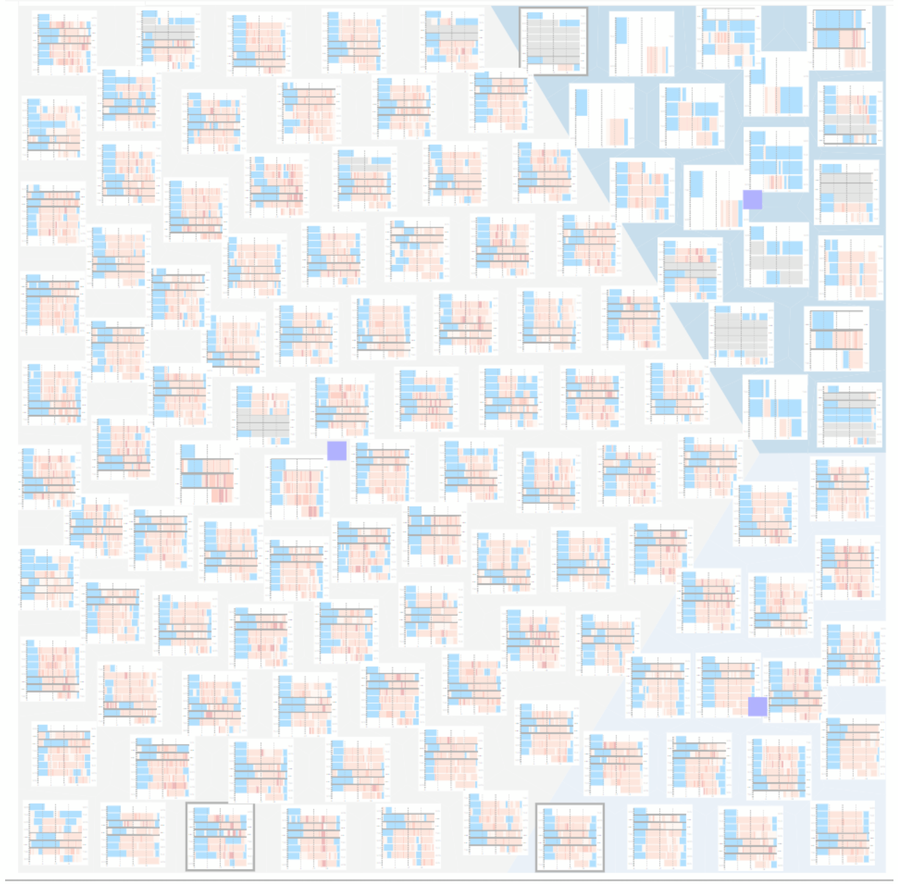
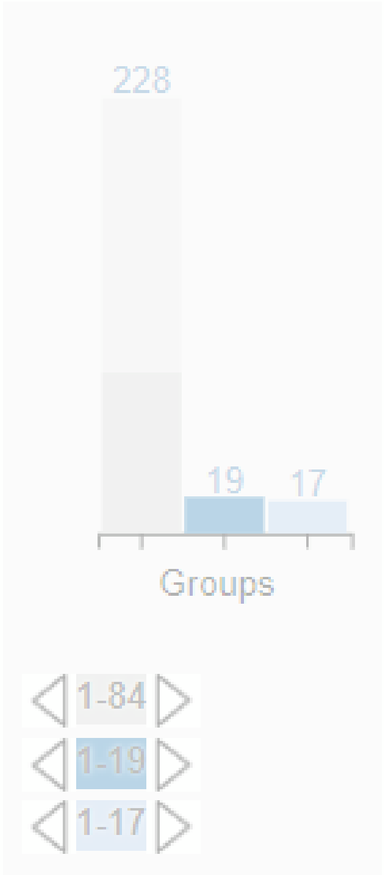
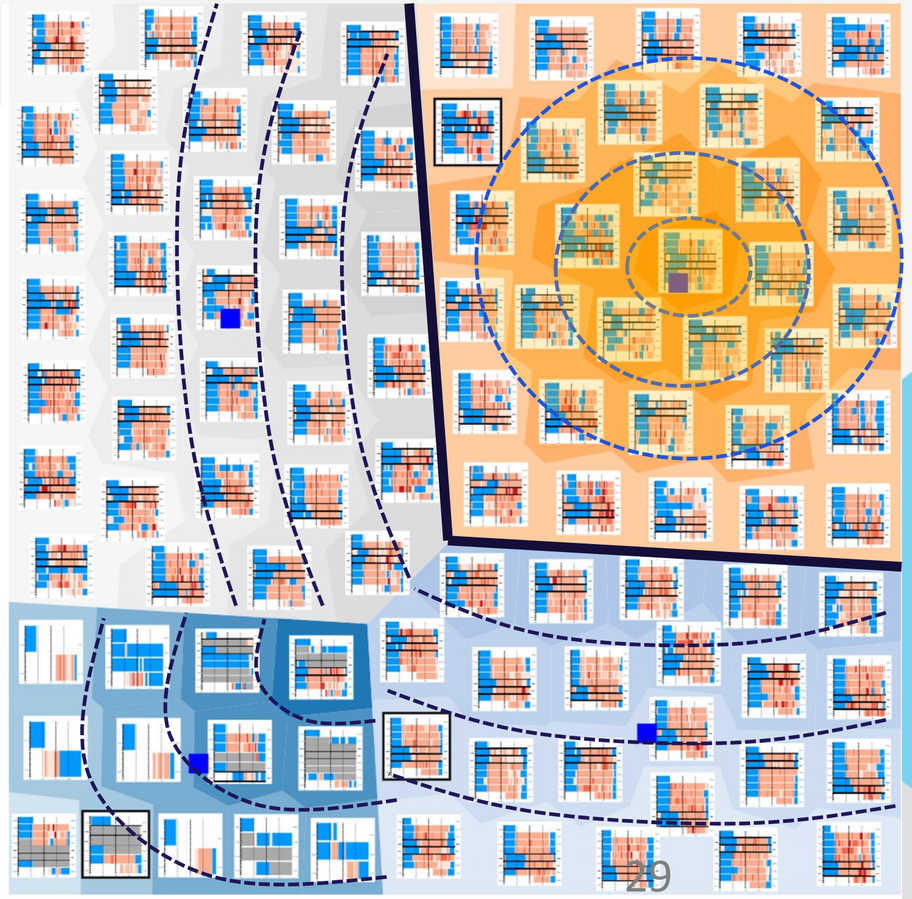




Graphical + Machine Learning features



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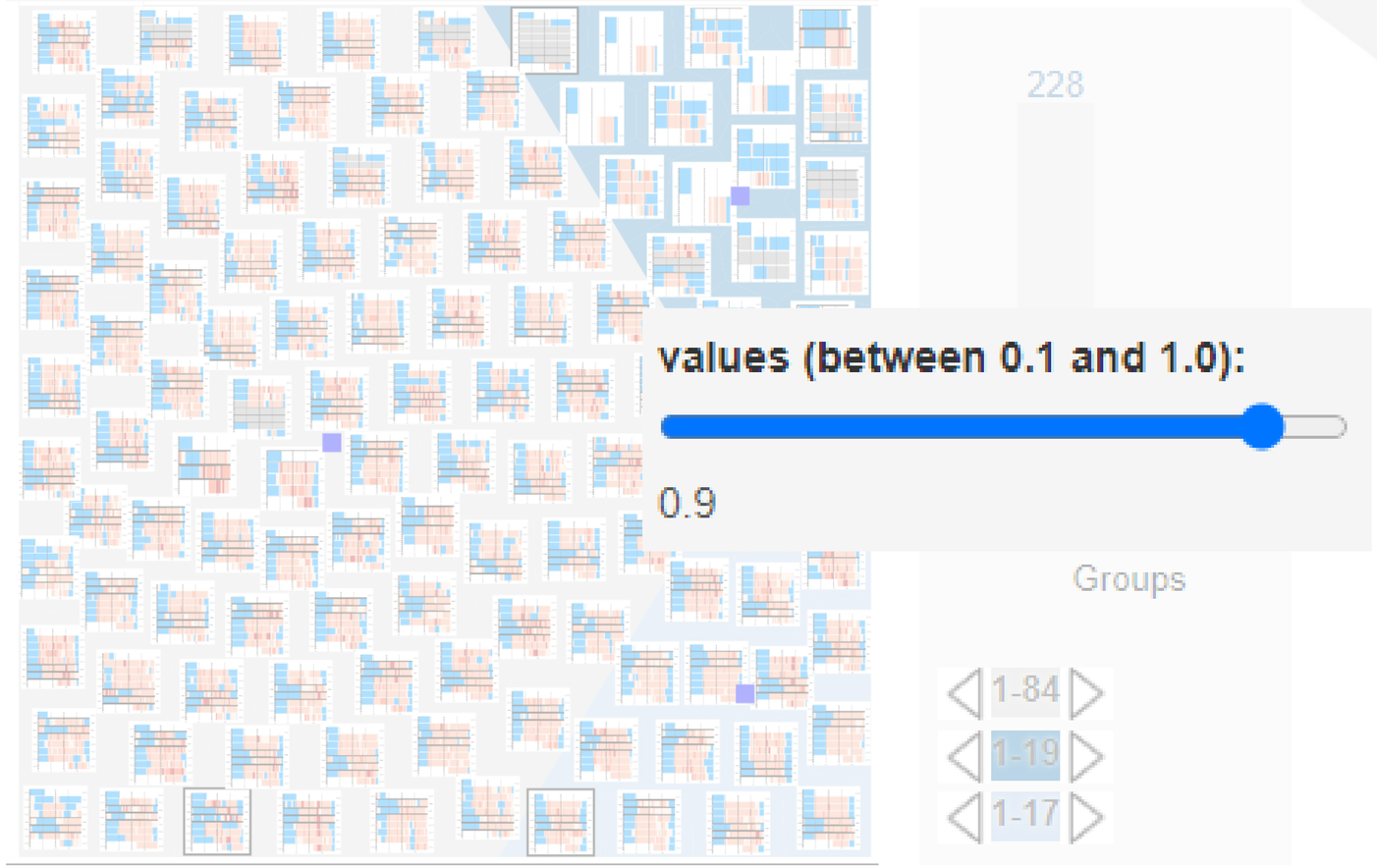

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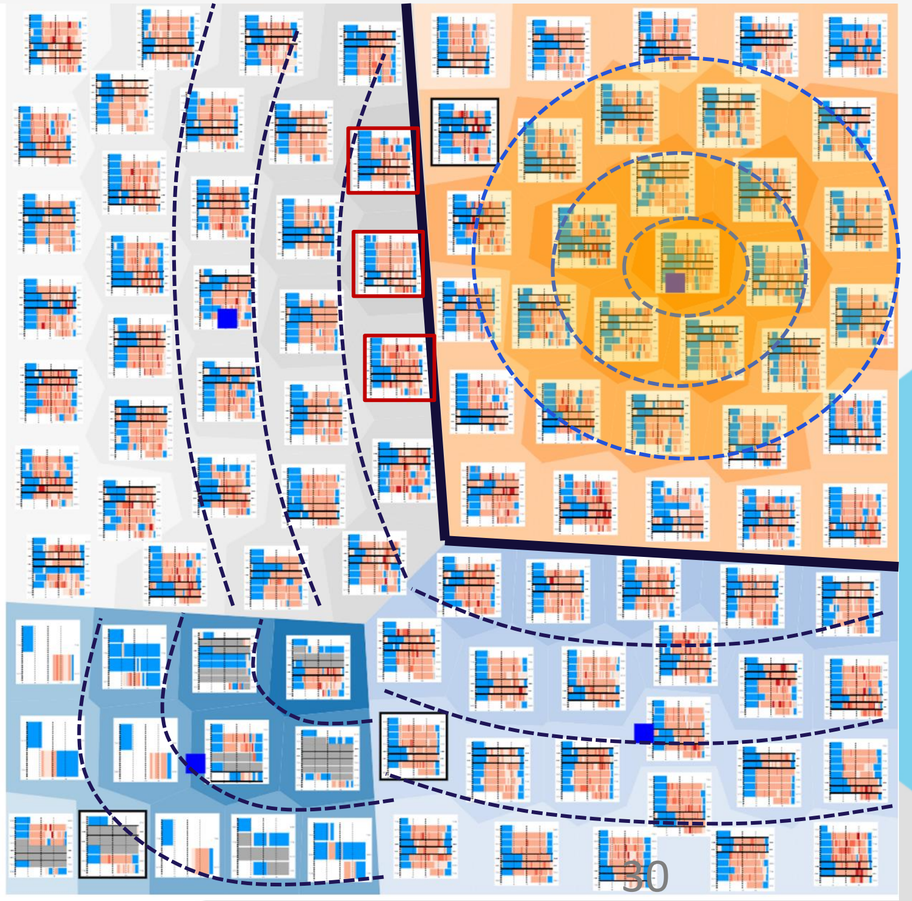

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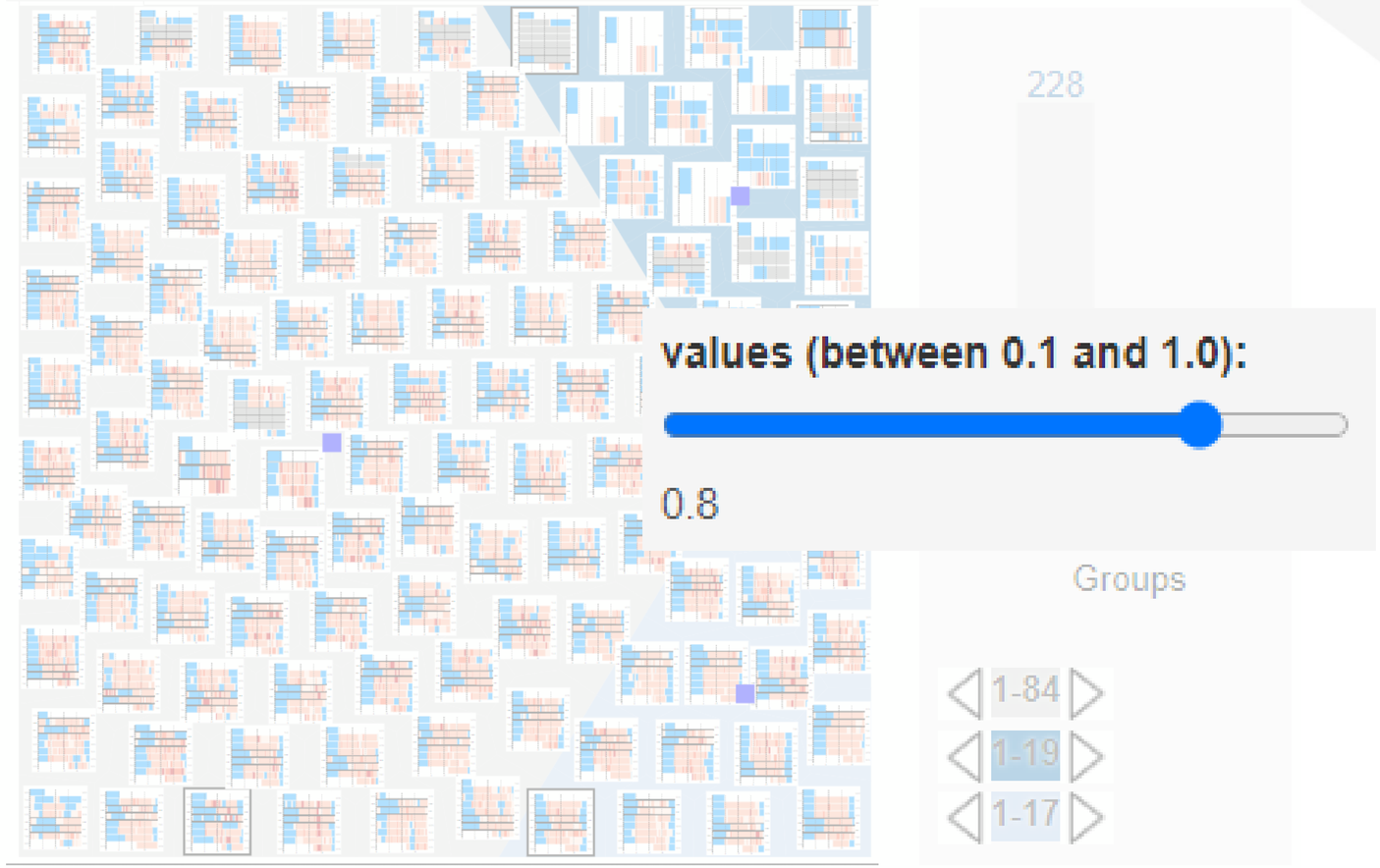

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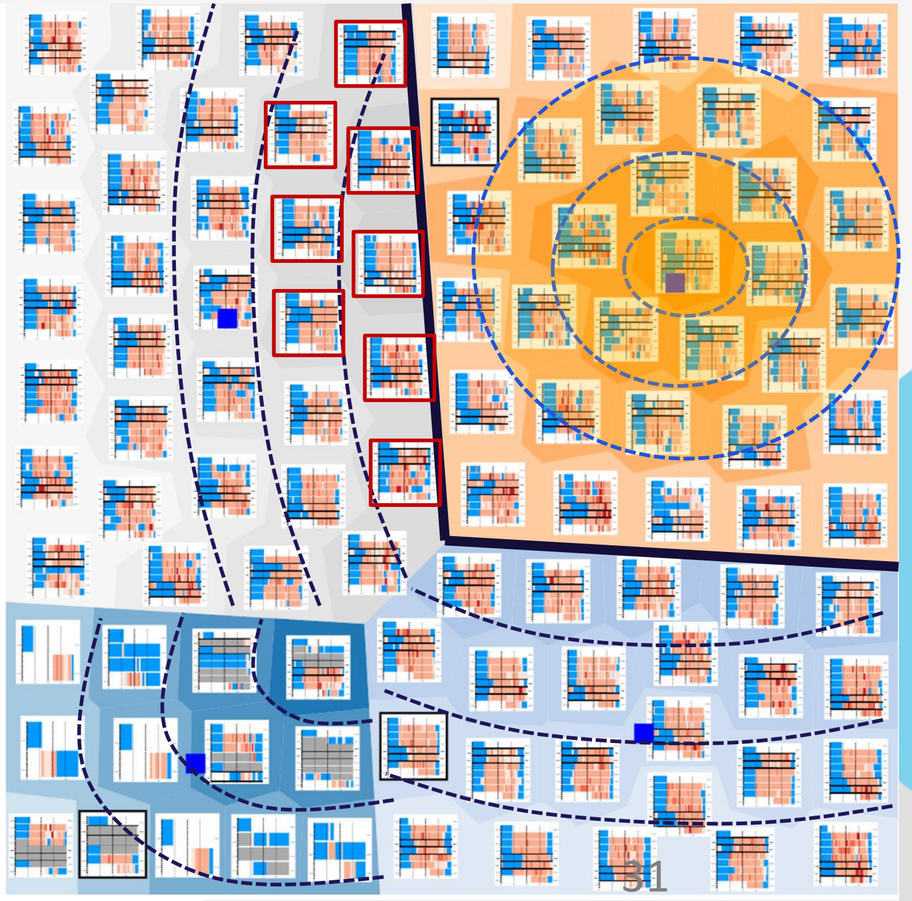

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Impact

- Raising **awareness of wearable technology potential** through multiple formative evaluation and collaborative design workshops with health care professionals.
- The **InViTAG system** final evaluation with HMC and Weill Cornell Medicine Qatar clinicians is planned for Summer 2023.

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Output

Ala Abuthawabeh, Michael Aupetit
Interactive visual data categorization systems and methods
US Patent granted on January 11, 2022 https://uspto.report/patent/grant/11,222,453

Benoît Colange, Jaakko Peltonen, Michaël Aupetit, Denys Dutykh, Sylvain Lespinats
Steering Distortions to Preserve Classes and Neighbors in Supervised Dimensionality Reduction
Neural Information Processing and Systems (NeurIPS 2020)
https://proceedings.neurips.cc/paper/2020/hash/99607461cdb9c26e2bd5f31b12dcf27a-Abstract.html

Kamran Khowaja, Wafa Waheeda Syed, Meghna Singh, Shahrad Taheri, Odette Chagoury, A. Dena Al-Thani, Michaël Aupetit.
Participatory Design Approach to develop Visualization of Wearable Actigraphy Data for Healthcare Professionals: A Case Study in Qatar
JMIR Human Factors 9 (2), **2022**
https://humanfactors.jmir.org/2022/2/e25880

Ala Abuthawabeh, Abdelkader Baggag, Michael Aupetit
Augmented Intelligence with Interactive Voronoi Treemap for Scalable Grouping: a Usage Scenario with Wearable Data
Short paper at **EuroVis 2022**
https://diglib.eg.org/handle/10.2312/evs20221091

Ala Abuthawabeh and Michael Aupetit
Toward an Interactive Voronoi Treemap for Manual Arrangement and Grouping
Short paper at **EuroVis 2021**
https://diglib.eg.org/handle/10.2312/evs20211062

Ala Abuthawabeh and Michael Aupetit
A Force-Directed Power Diagram Approach for Interactive Voronoi Treemaps
Short paper at **EuroVis 2020**
https://diglib.eg.org/handle/10.2312/evs20201057

Ala Abuthawabeh and Michael Aupetit
Quiz game system in collaboration with Qatar Museums: https://quizgame.qcri.org/mathaf/

Cluster QNRF grant **NPRP11C-0115-180010 Qatar Diabetes Prevention Program**. WP7.3 Visual Analytics https://mis.qgrants.org/Public/AwardDetails.aspx?ParamPid=fhgkhjbpcc

QF Invention disclosure: D2022-0072. Abdelkader Baggag, Michael Aupetit "Augmented Intelligence System for Patient Health Improvement based on Wearable Data"