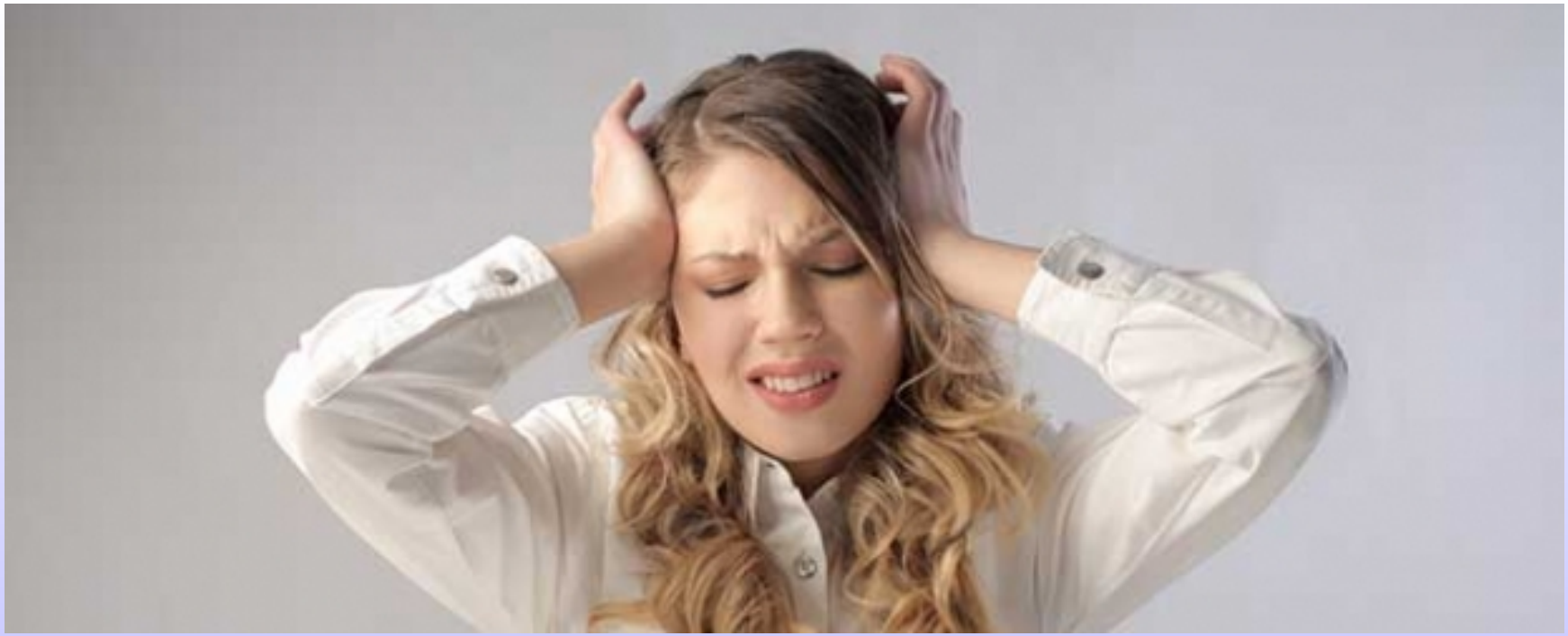
Design of a diagnosis and follow-up platform for patients with chronic headaches

Kiani Lannoye & Gilles Vandewiele

Faculty of Engineering and Architecture

Headaches



Headaches

Headaches

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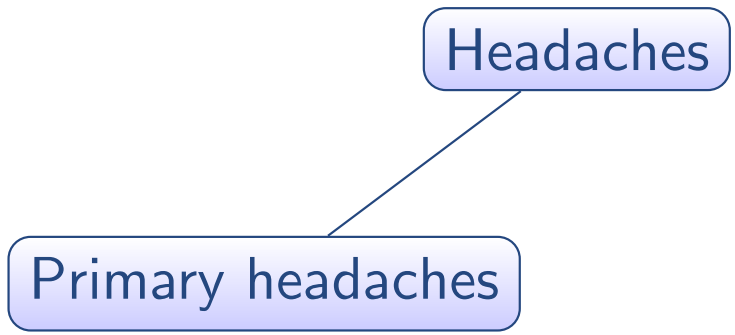
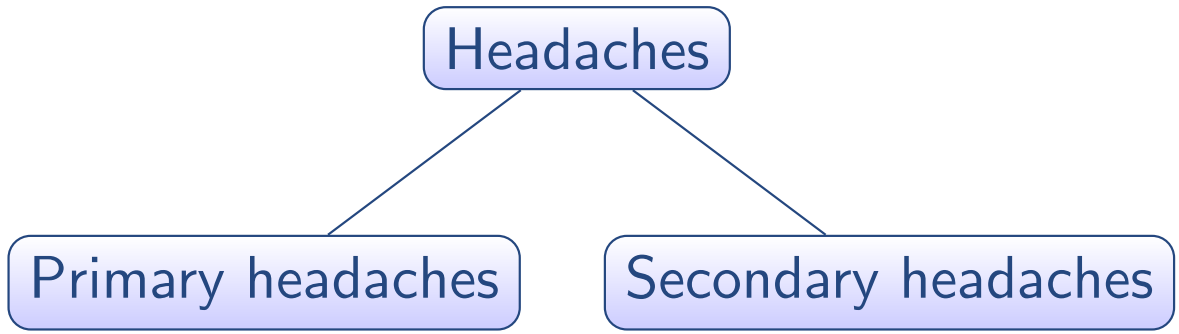
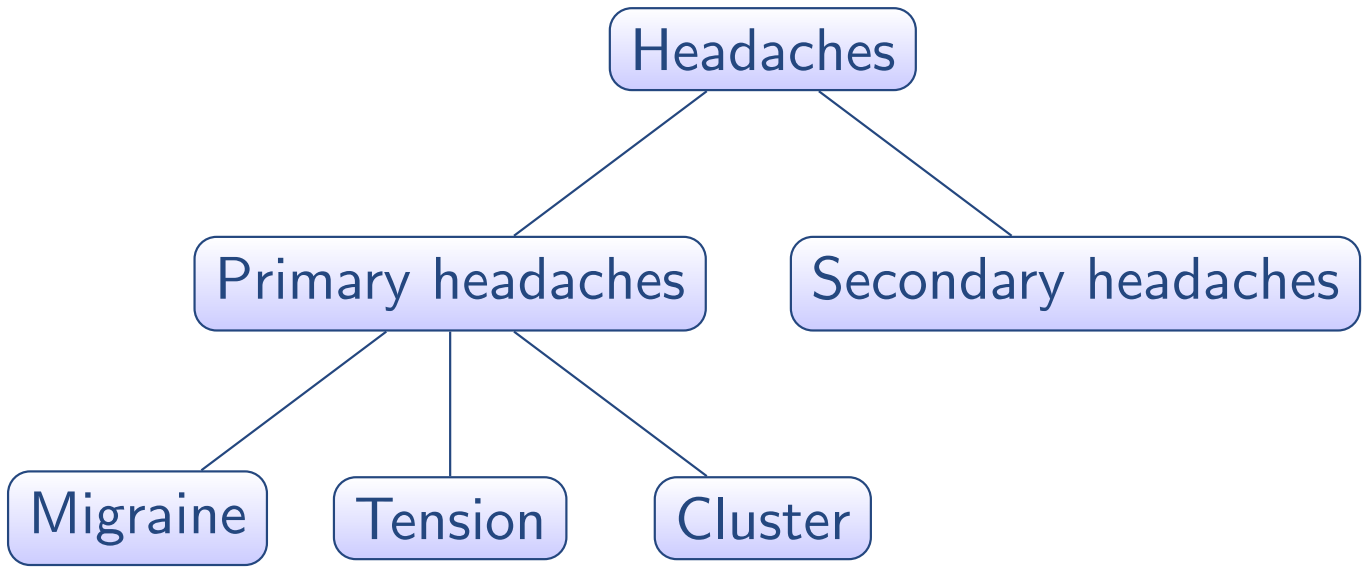


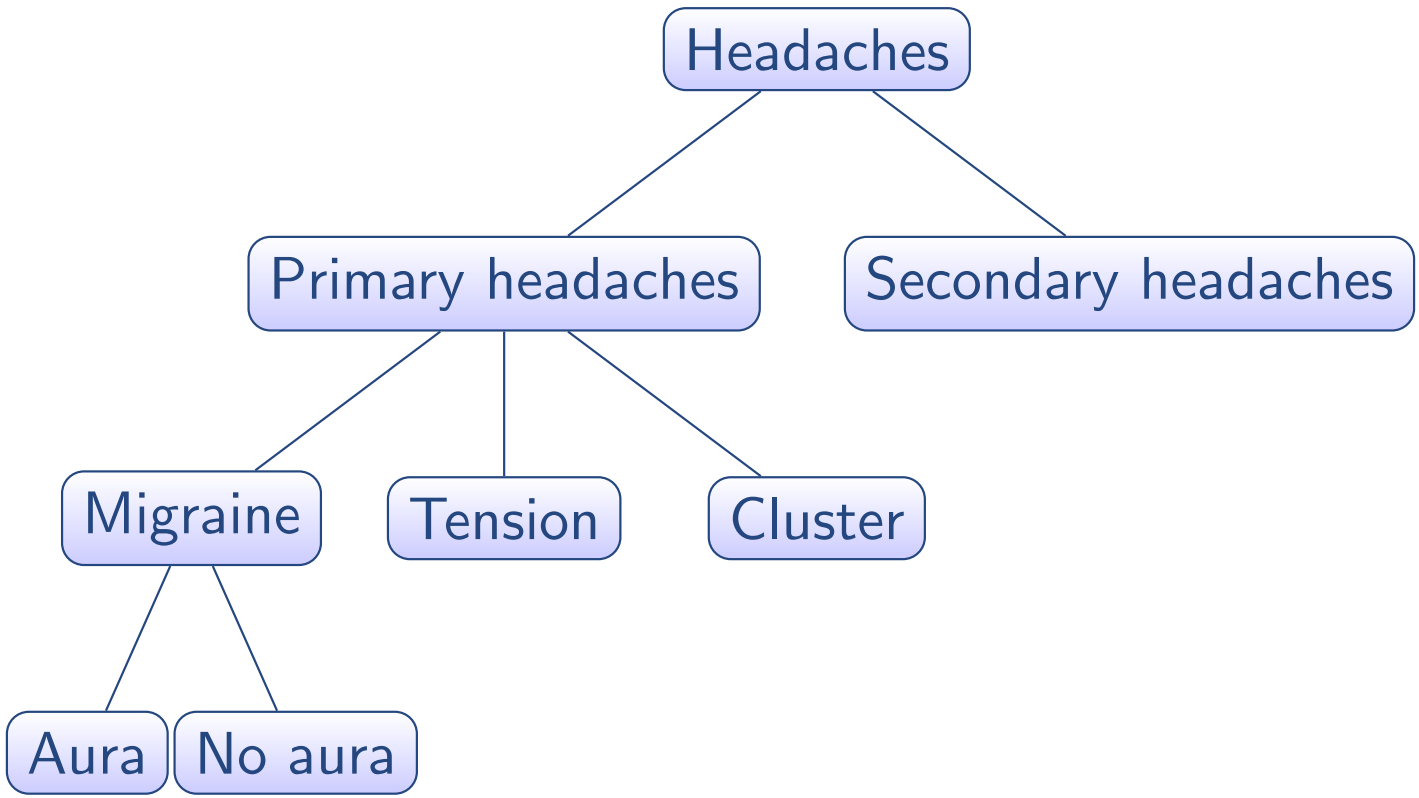
Headaches



Headaches


Headaches
Primary headaches
Secondary headaches
Migraine
Tension
Cluster

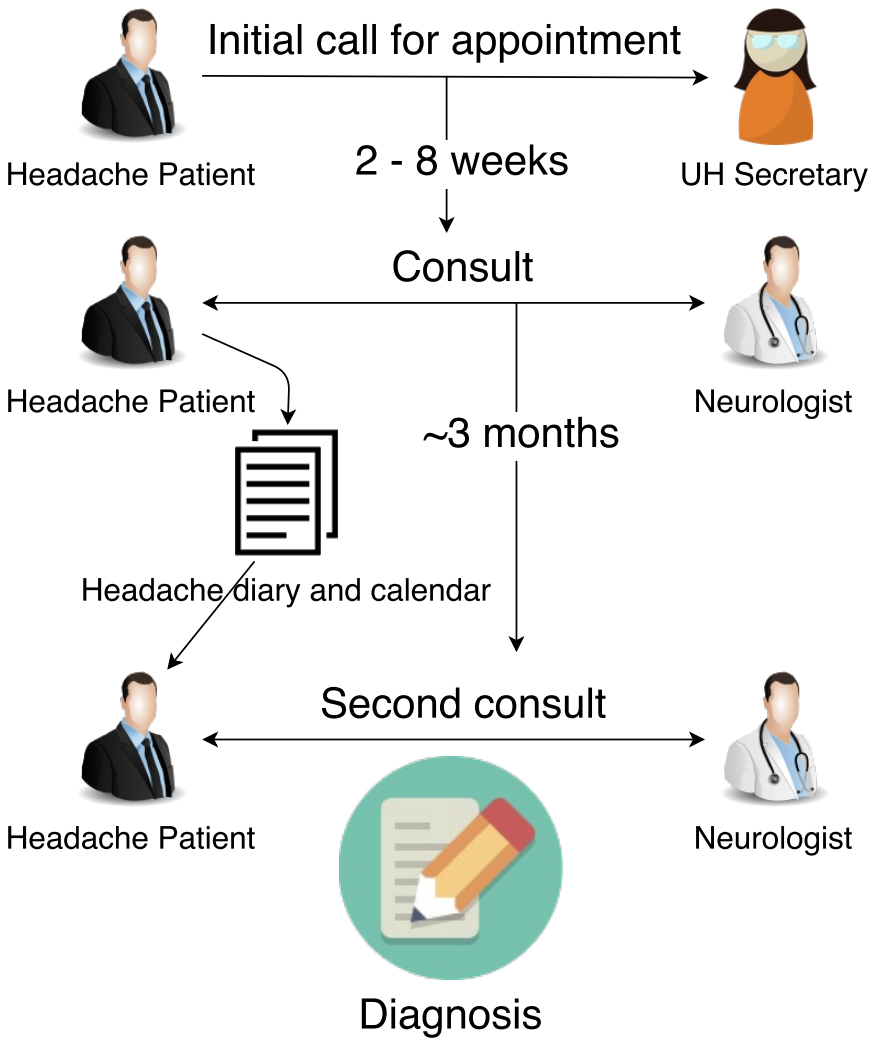
Headaches


Headaches
Primary headaches
Secondary headaches
Migraine
Tension
Cluster
Aura
No aura

Current process UH Ghent

Current process at UH Ghent is:

- Not digital
- cumbersome
- long-lasting


Initial call for appointment
Headache Patient
2 - 8 weeks
UH Secretary
Consult
Headache Patient
Neurologist
~3 months
Headache diary and calendar
Second consult
Headache Patient
Neurologist
Diagnosis

So there is need for a better (digital) alternative! This alternative has to:

- capture at least the same information as current solution
- be more efficient
- provide a second opinion for the doctors (auto-diagnose)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Platform requirements

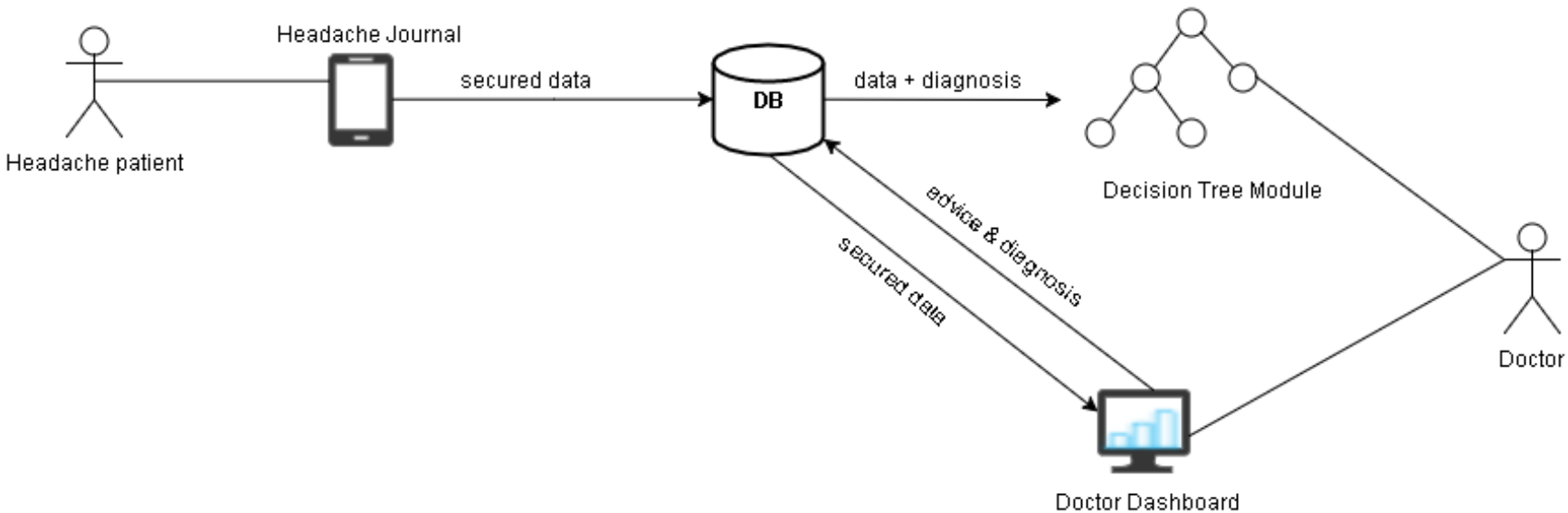
Our proposed alternative consists of:

- Headache journal: mobile app
- Doctor Dashboard: web application
- Machine learning module: auto-classify

Solution non-functional requirements:

- Security
- Availability
- Performance
- Usability

Platform requirements



Mobile Application

Why create a new application?

Competition

- Migraine Buddy
- Headache Diary
- Pfizer headache journal

Mobile Application

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All good, but:

Mobile Application

Why create a new application?

Competition

- Migraine Buddy
- Headache Diary
- Pfizer headache journal

All good, but:

- none offers usable data export
- none captures all data needed

Cross platform vs Native

	Native	**Cross-platform**
+	+ Native UX + device-specific features + Better performance	+ 1 language + Write once, run everywhere + Less maintenance
-	- Multiple languages - Time consuming (development)	- Slower (lower performance) - Less device specific features - Harder to release online (Play Store/App Store)

Cross platform vs Native

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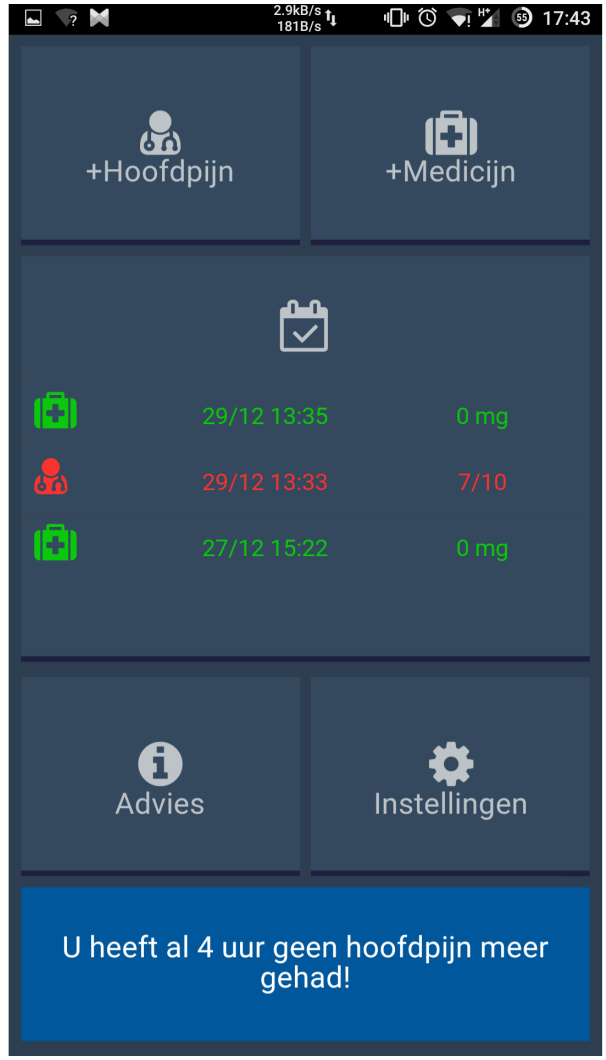
HTML
CSS
Onsen UI
PhoneGap

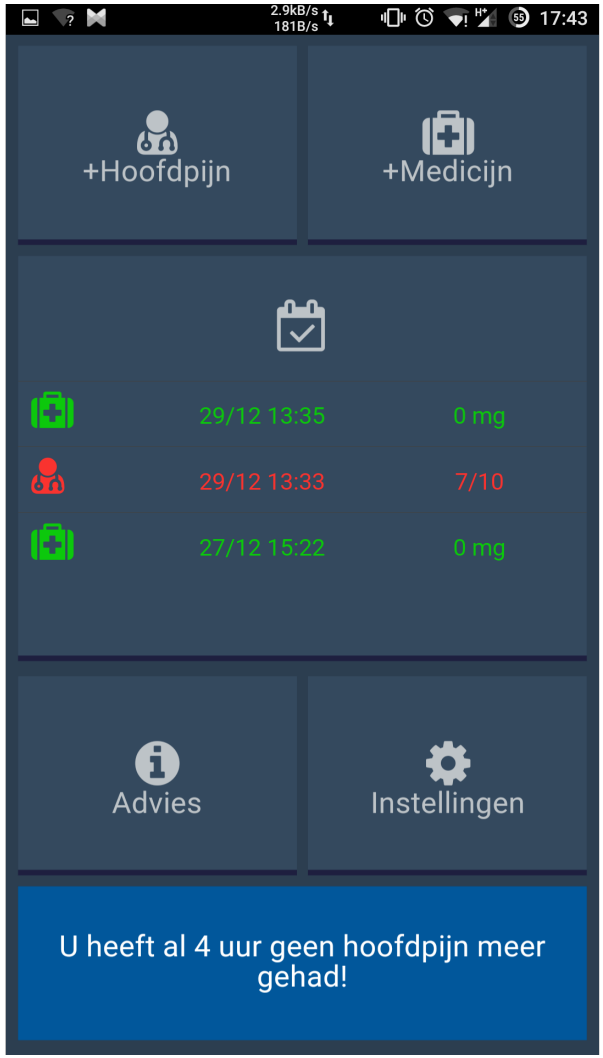

2.9kB/s
181B/s
17:43
+Hoofdpijn
+Medicijn
29/12 13:35
0 mg
29/12 13:33
7/10
27/12 15:22
0 mg
Advies
Instellingen
U heeft al 4 uur geen hoofdpijn meer gehad!

HTML

CSS

Onsen UI

PhoneGap



Chronicals

Chronicals


17:44
Terug
29 dec. 17:44
?
Locatie
Toon op welke plaats(en) u pijn voelt.
Tip: u kan het model draaien
Annuleer
Overslaan
Volgende

Chronicals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Volgende


13:09
Terug
29 dec. 17:44
?
Braken
Gevoeligheid aan inspanning
Misselijkheid
Gevoeligheid aan licht
Gevoeligheid aan geluid
Gebrek aan eetlust
Hoofdpijn omschrijving
Autonoom
Aurasymptomen
Visueel aura
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Motorisch aura
Spraakproblemen
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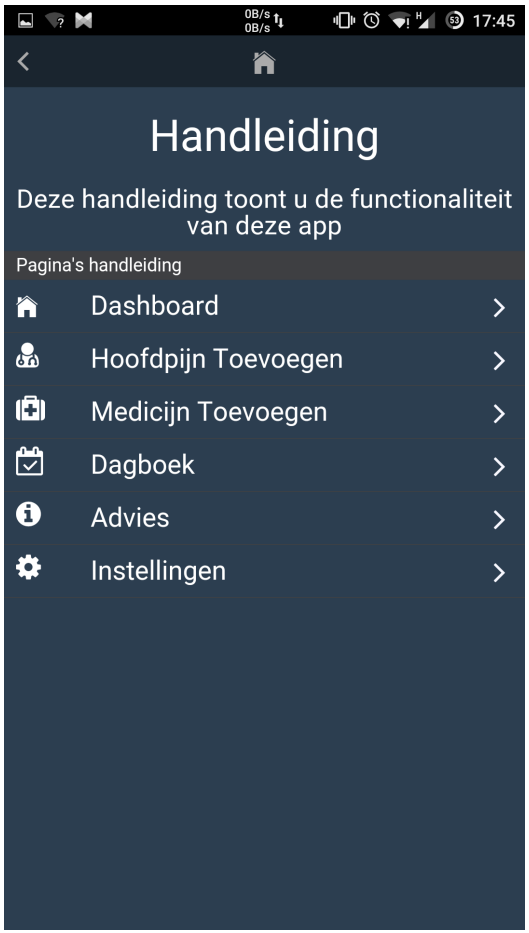
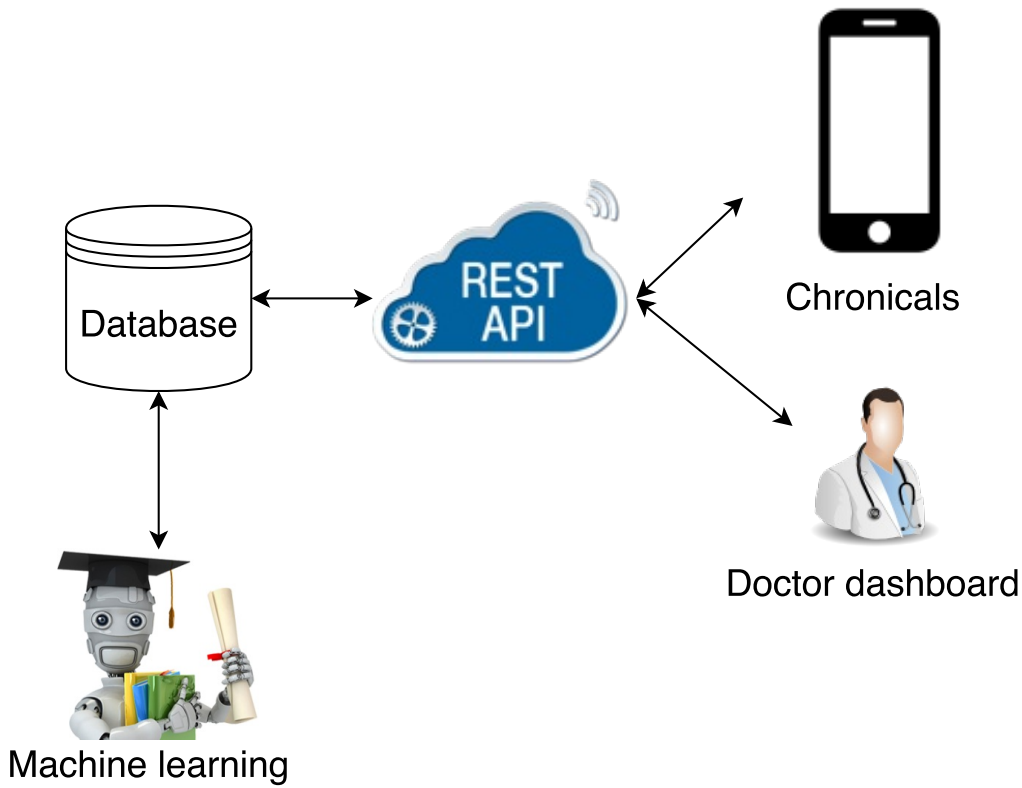

17:45
Handleiding
Deze handleiding toont u de functionaliteit van deze app
Pagina's handleiding
Dashboard
Hoofdpijn Toevoegen
Medicijn Toevoegen
Dagboek
Advies
Instellingen

Backend and data exposure

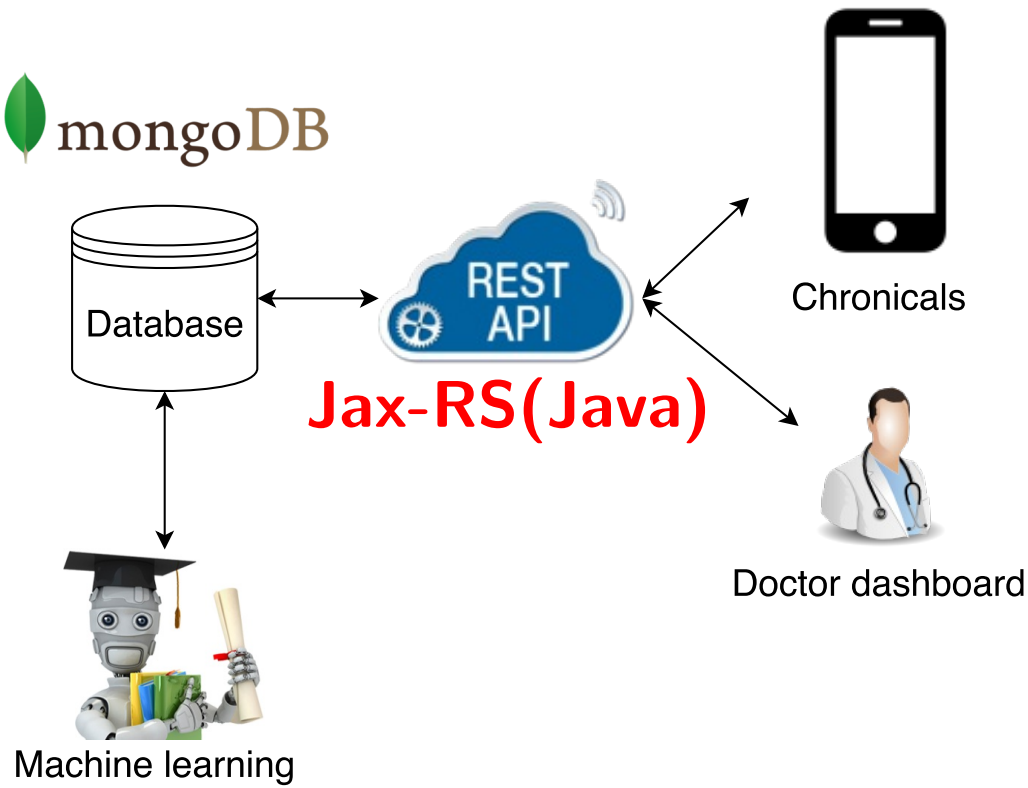
Components

- Database
- Connection to App
- Connection to Docter Dashboard
- Connection Machine learning module

System


Database
REST API
Chronicals
Doctor dashboard
Machine learning

System


mongoDB
Database
REST API
Jax-RS(Java)
Chronicals
Doctor dashboard
Machine learning

Many different induction algorithms

C4.5 (C5.0)

CART

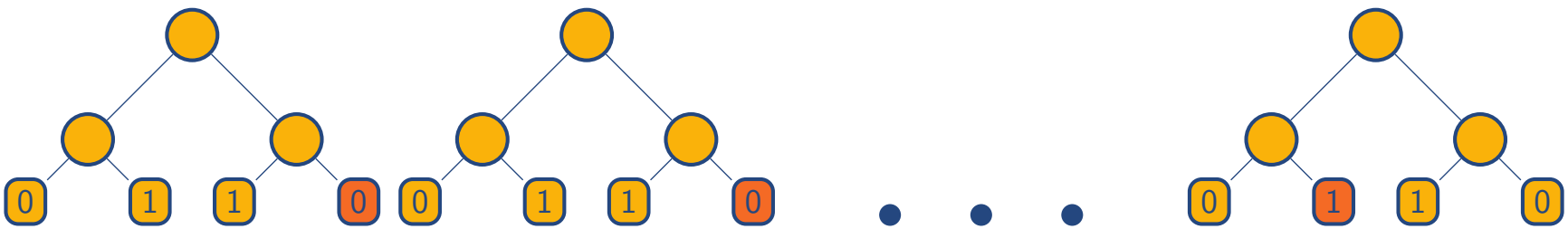
QUEST

...

→ **Which tree is the most beautiful?**

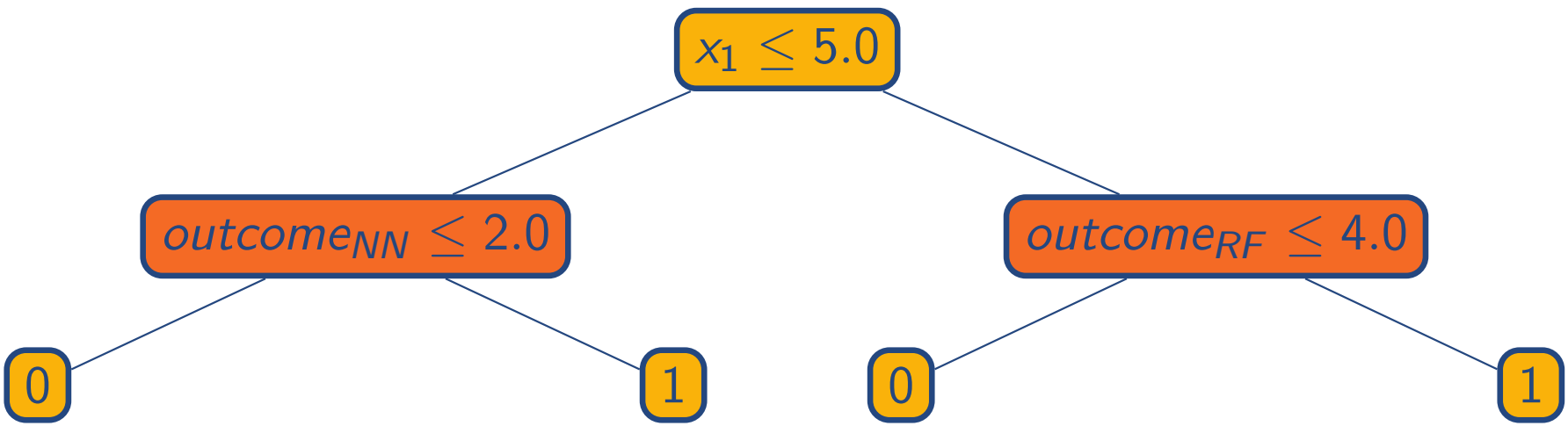
Current ensembles lack interpretability

Boosting, bagging, random forests, etc. require majority voting (classification) or mean calculation (regression) to obtain prediction



Current ensembles lack interpretability

The final decision tree obtained by **stacking** contains uninterpretable internal nodes

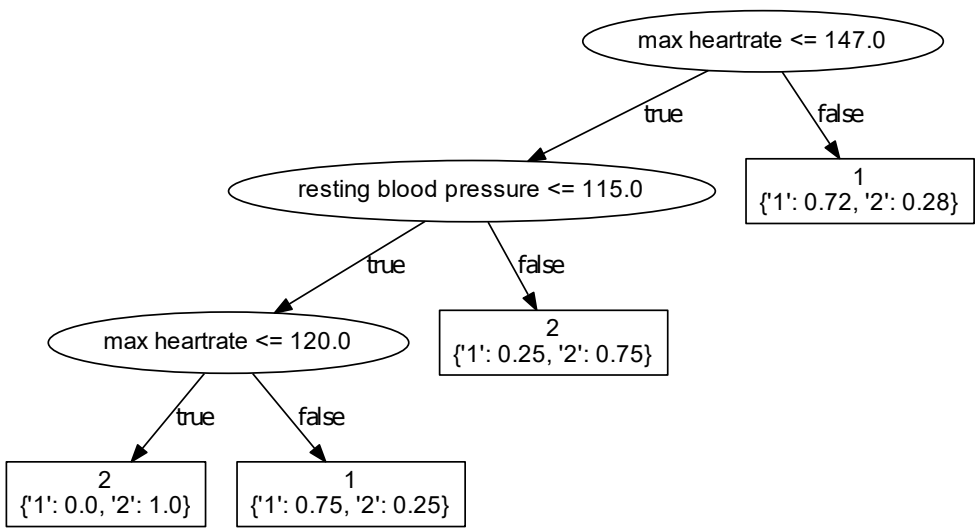


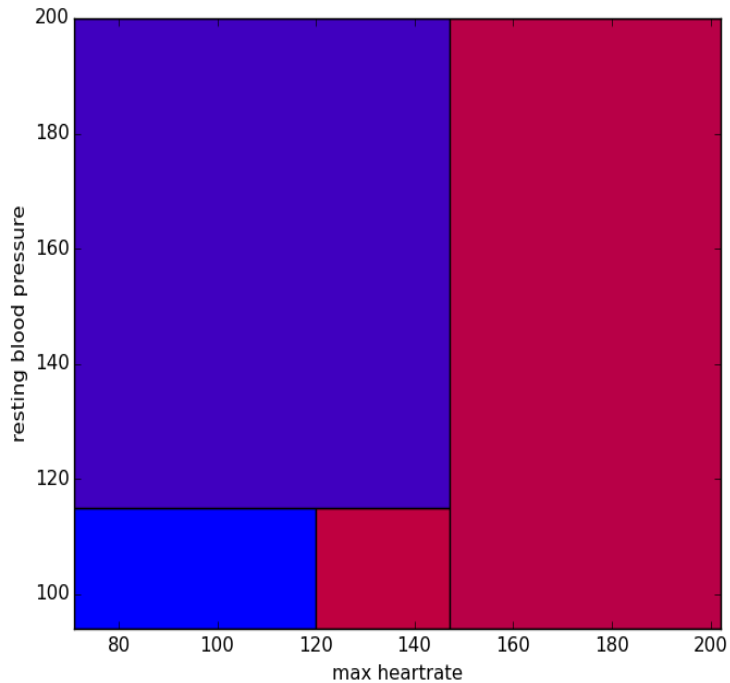
Decision tree $\rightarrow$ decision space

Converting decision trees to decision spaces

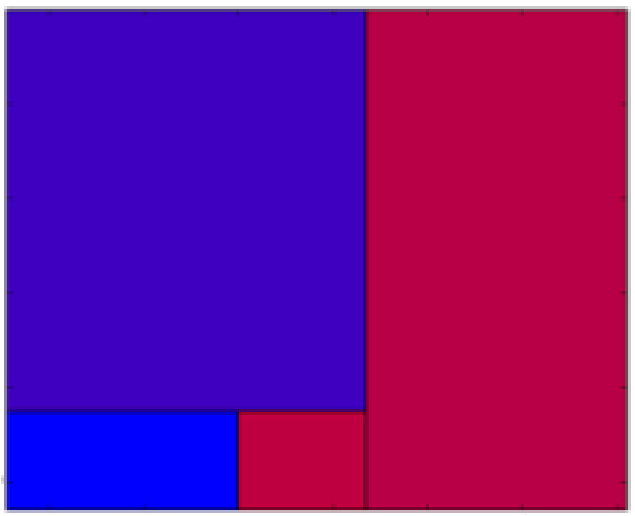
We can define a one-to-one mapping between a decision tree and a set of k-dimensional hyperplanes ($k = \#\text{features}$), called **decision space**. Each node in the decision tree corresponds to a hyperplane in the decision space.

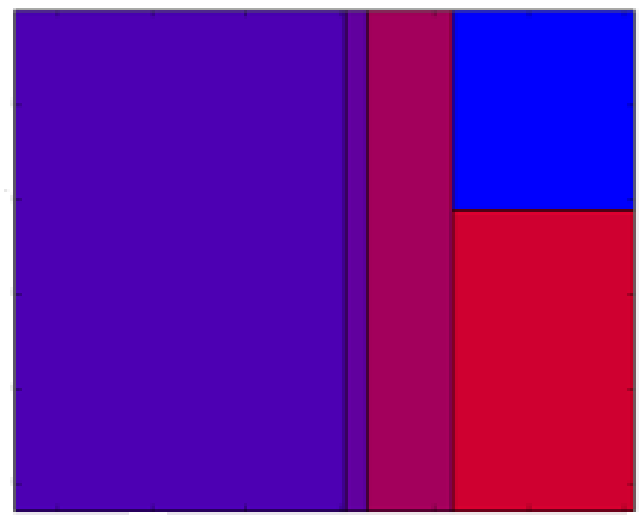
Decision tree → decision space



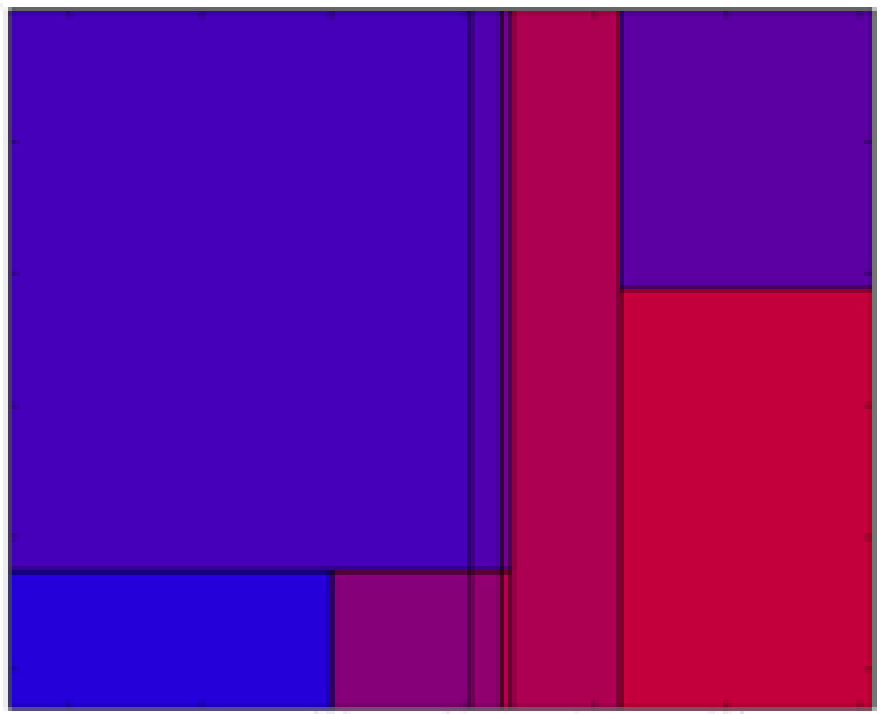


Merging decision spaces

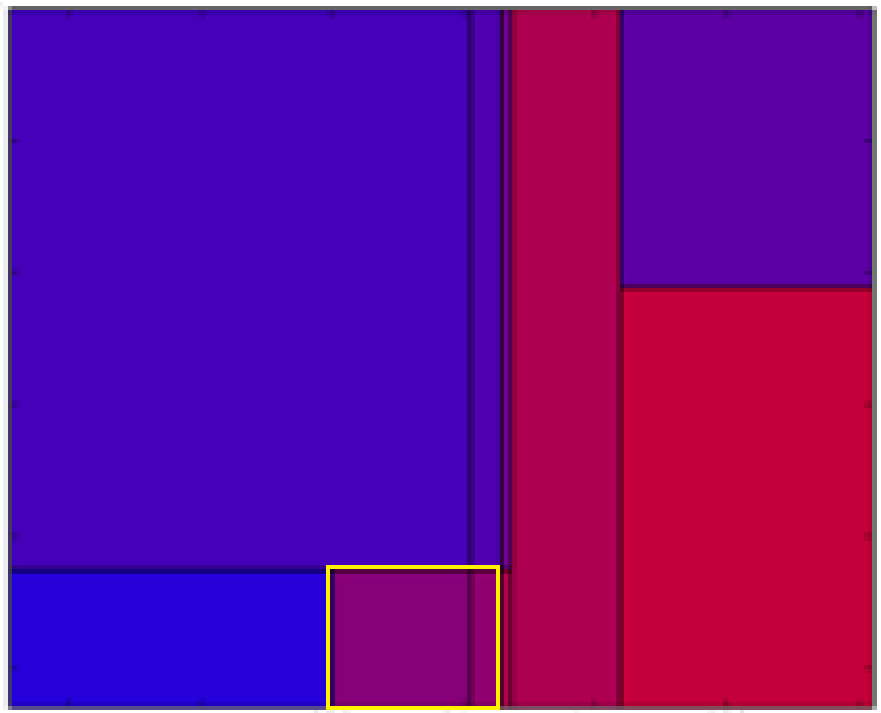




Merging decision spaces



Pruning decision spaces



Decision space $\rightarrow$ decision tree

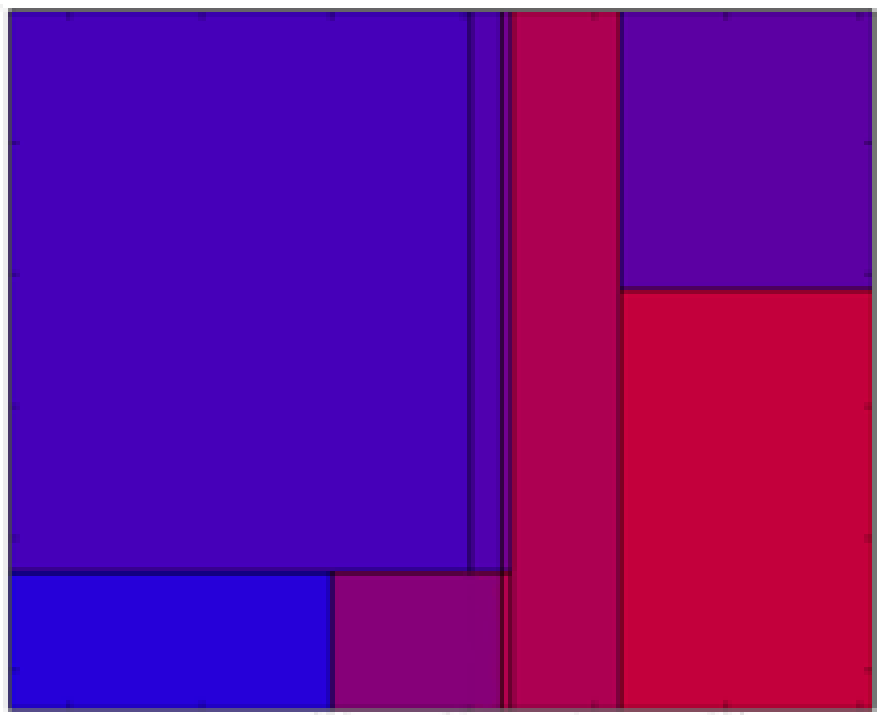
Converting decision spaces to decision trees

One-to-one mapping from decision tree to space is lost during conversion because the order is lost. Therefore, a heuristic approach must be taken, identifying hyperplane candidates and calculating a metric to choose the 'best' plane.

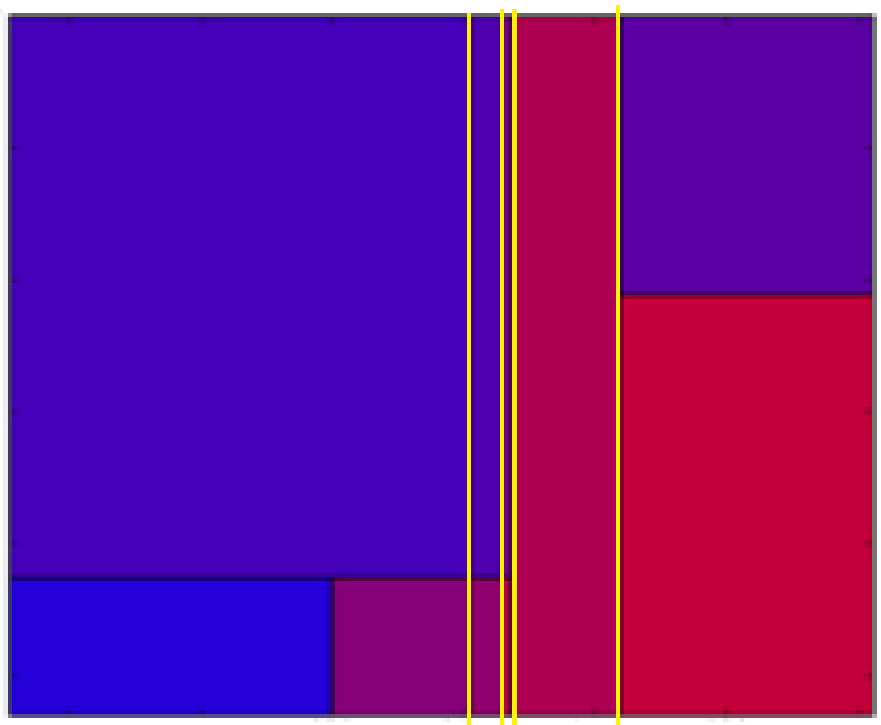
Candidate hyperplanes

In order for a plane to be the next candidate node, it must be unbounded in all dimensions but one.

Decision space $\rightarrow$ decision tree



Decision space $\rightarrow$ decision tree

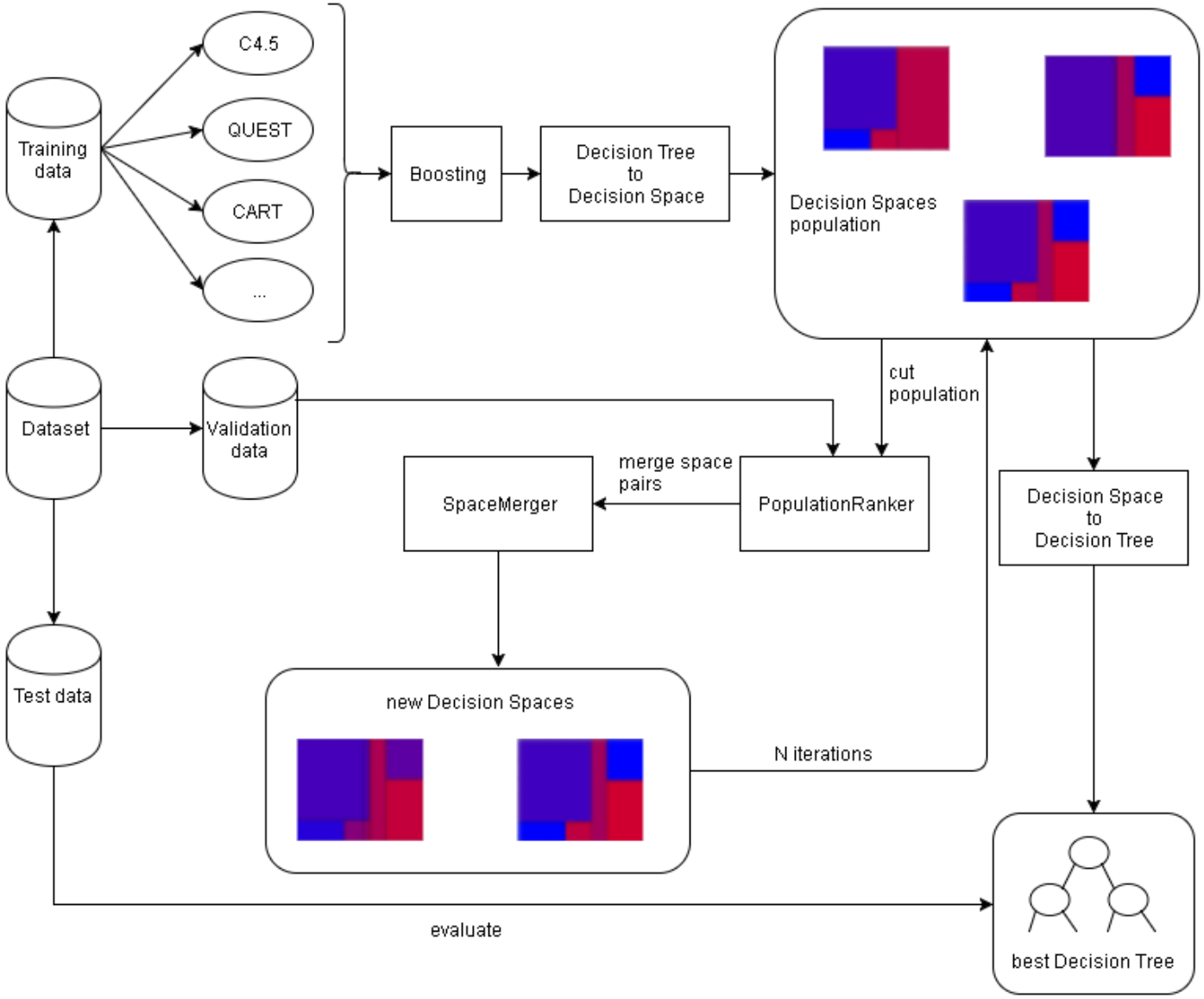


Decision space $\rightarrow$ decision tree

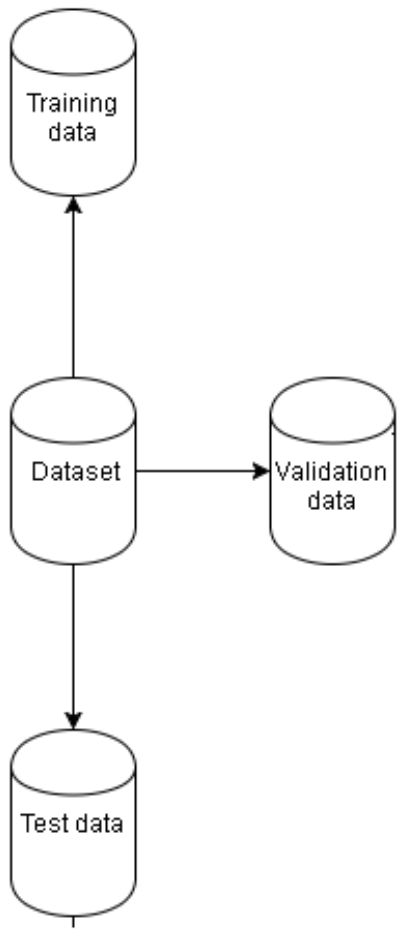
Finding 'best' candidate hyperplane

Apply metric function to each plane, these include:

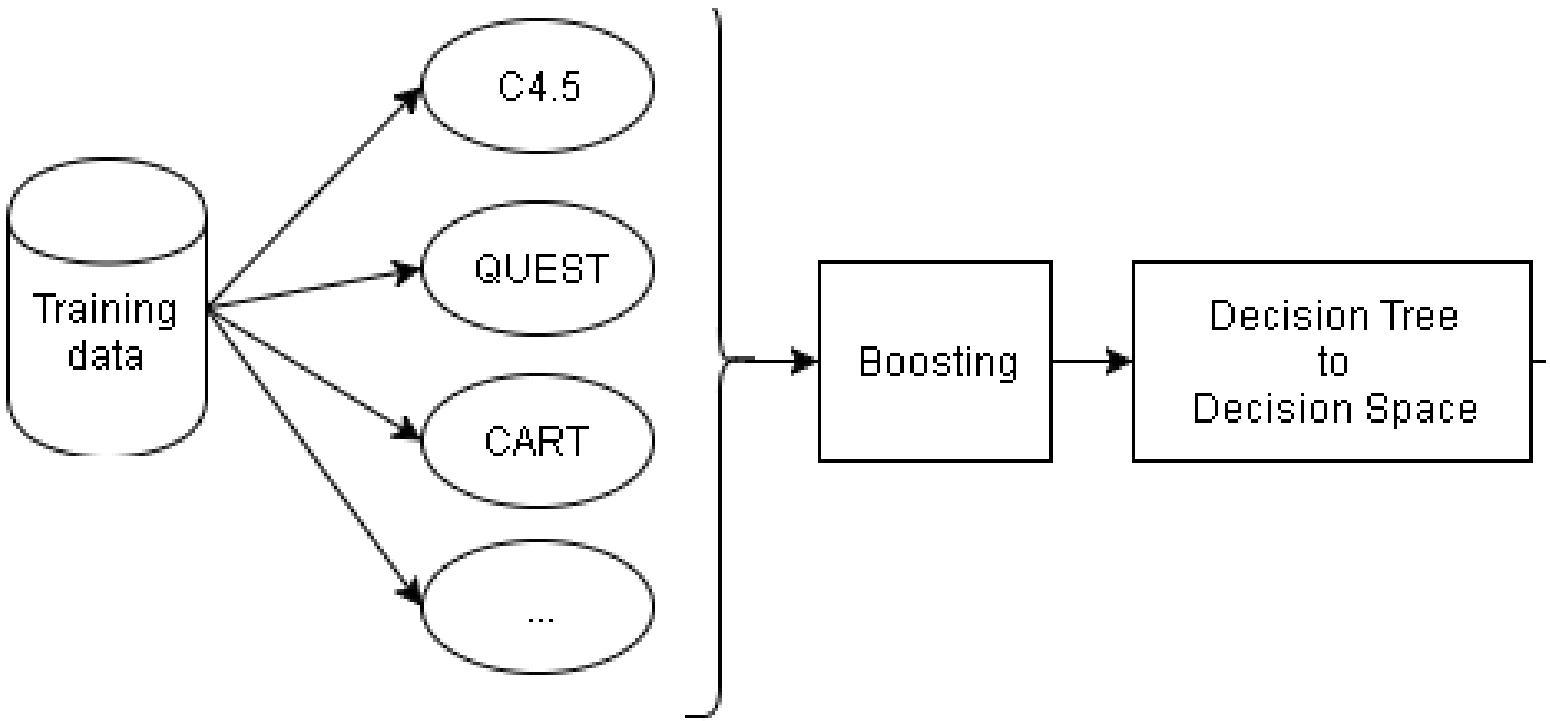
- information gain and Gini from C4.5 and CART respectively
- pick plane from most correlated feature (χ^2- and ANOVA F-test from QUEST)
- pick plane that divide space in two most equal subspaces (using surface/volume or counting number of planes)
- combination


C4.5
QUEST
CART
...
Training data
Boosting
Decision Tree to Decision Space
Decision Spaces population
cut population
Dataset
Validation data
SpaceMerger
merge space pairs
PopulationRanker
Decision Space to Decision Tree
Test data
new Decision Spaces
N iterations
evaluate
best Decision Tree

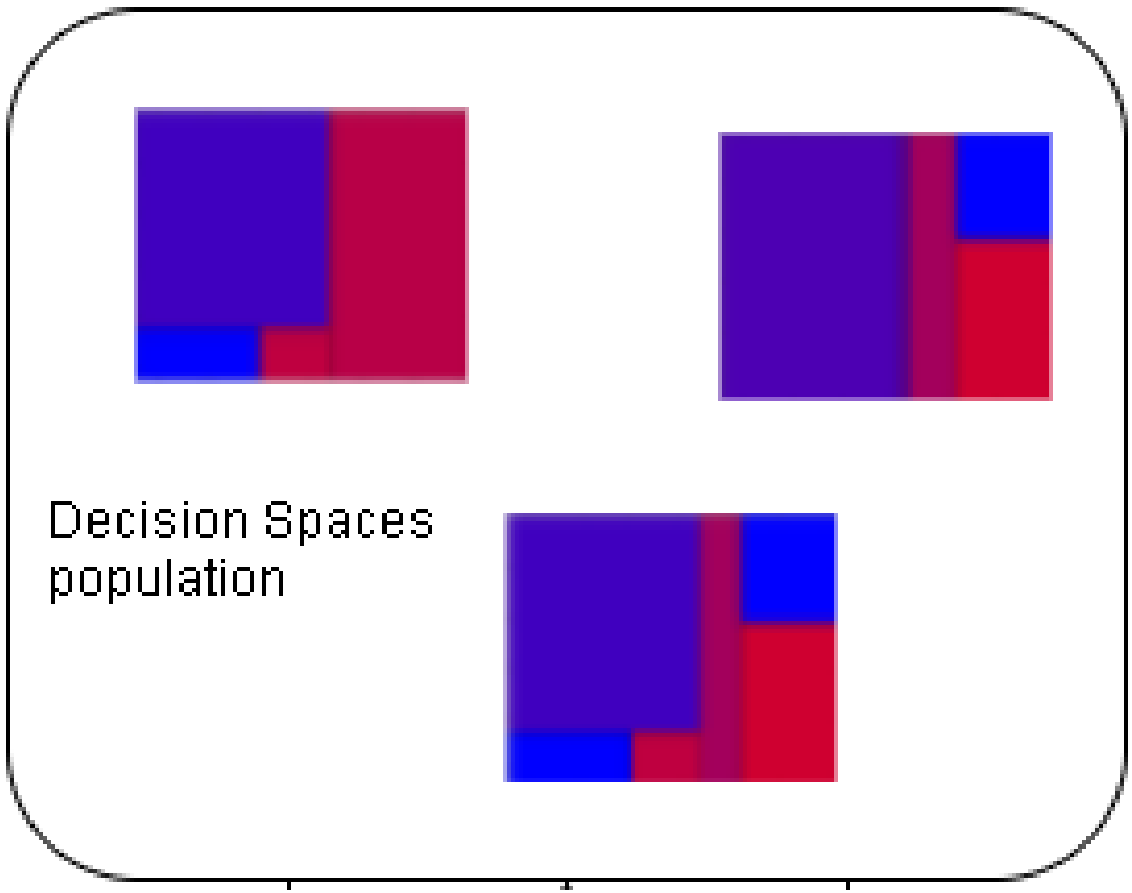
Splitting the data



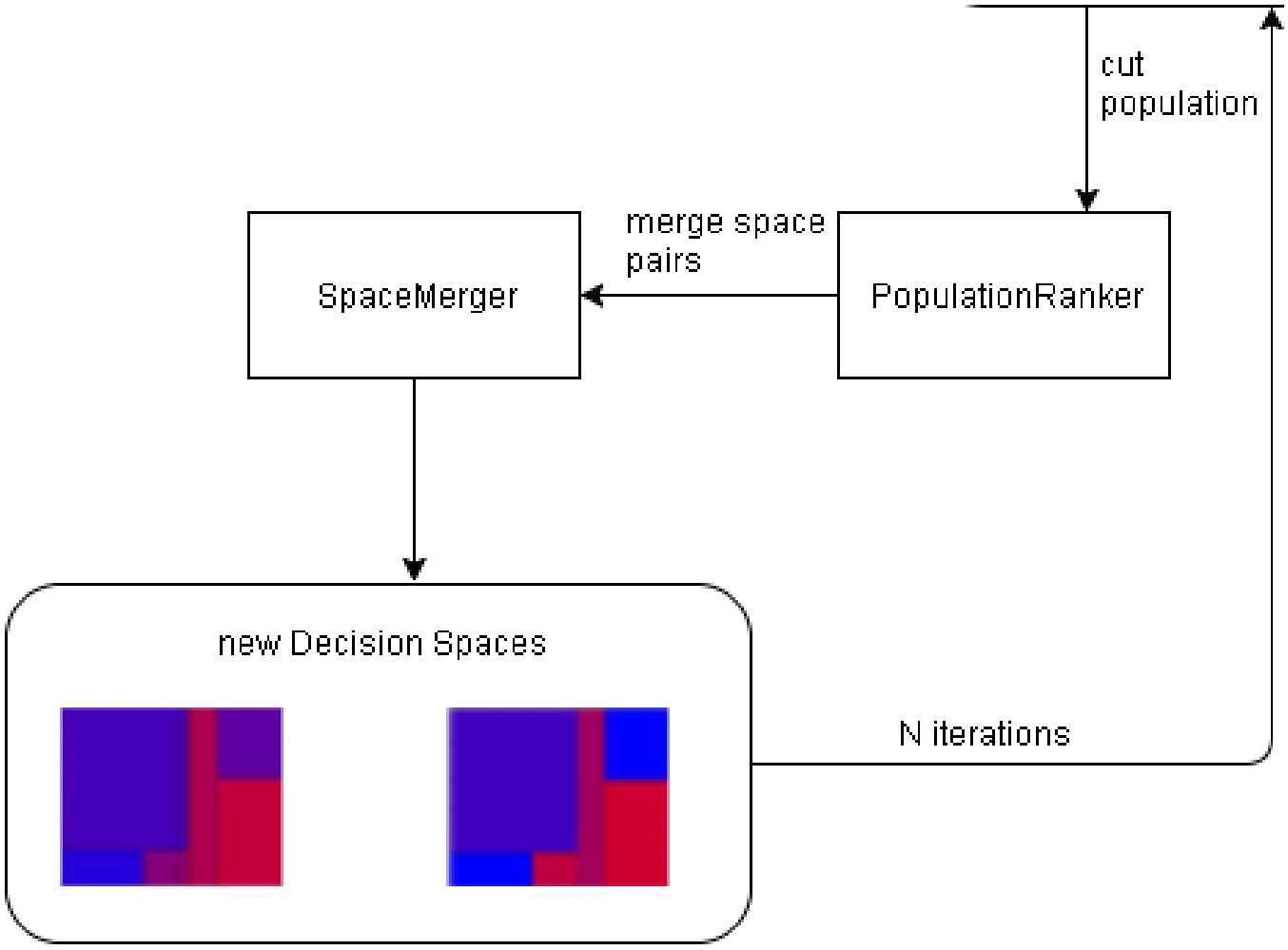
Generate different decision trees



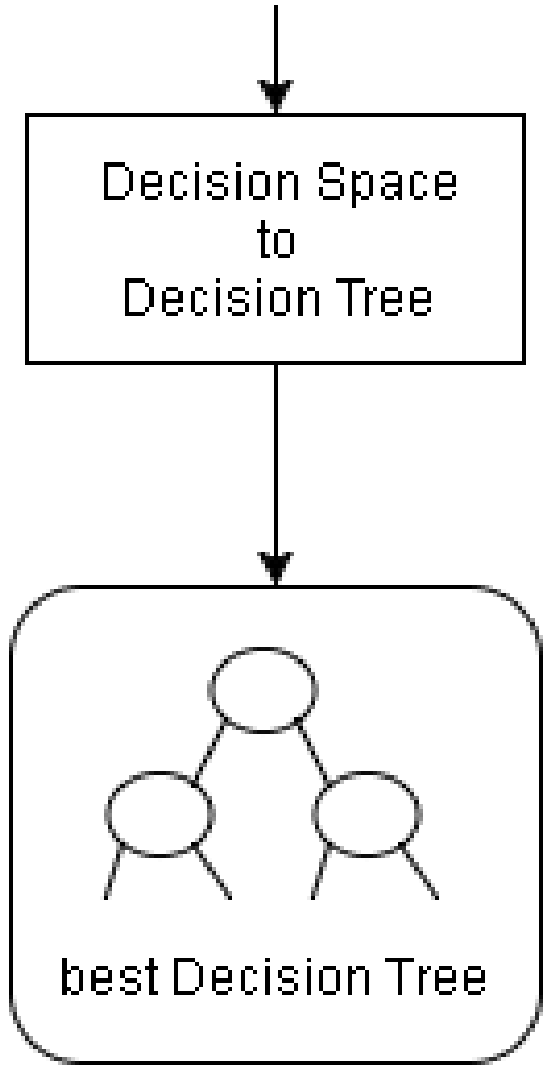
Generate different decision trees

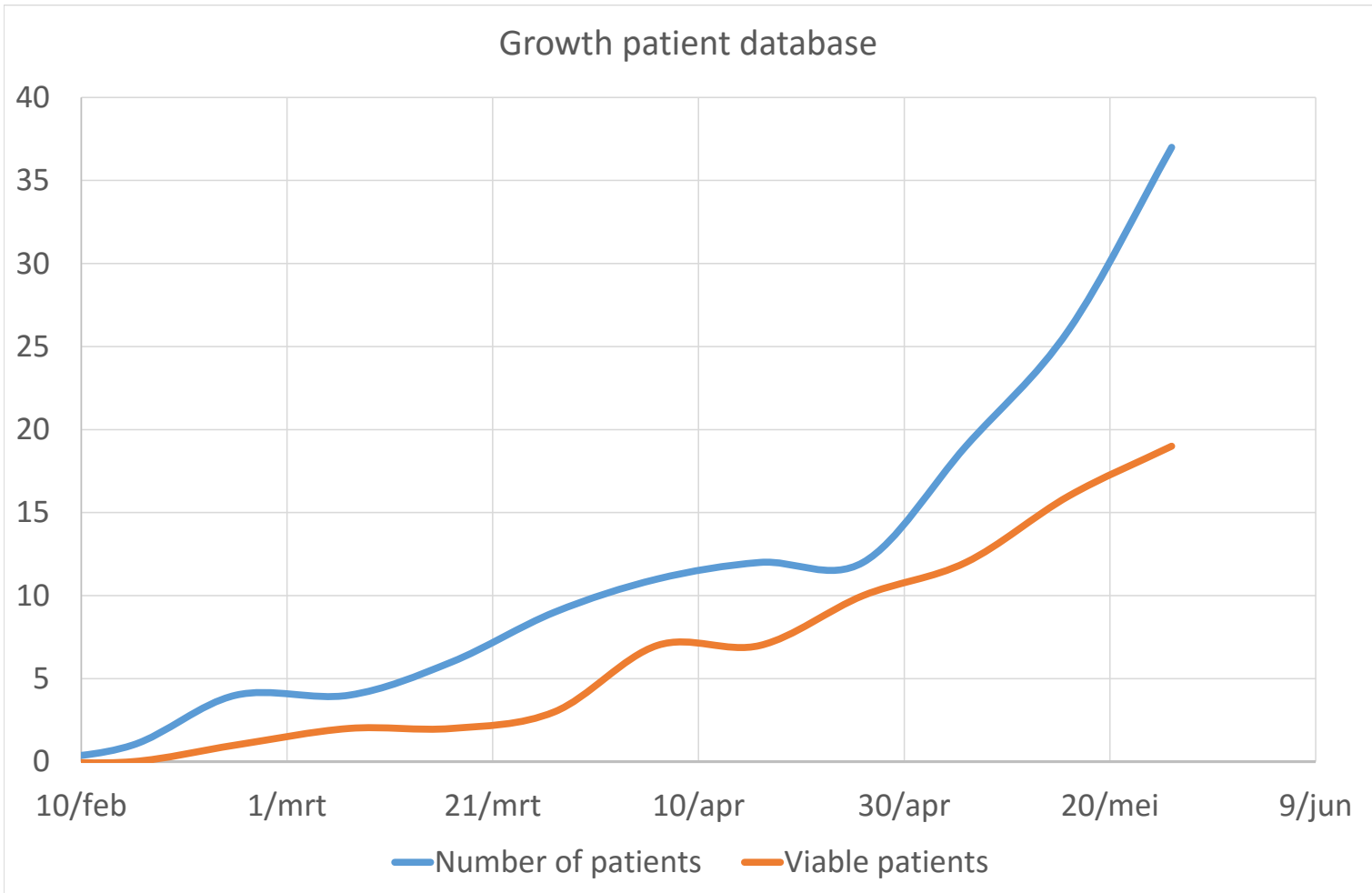


Genetic merging



Final iteration




Growth patient database
40
35
30
25
20
15
10
5
0
10/feb
1/mrt
21/mrt
10/apr
30/apr
20/mei
9/jun
Number of patients
Viable patients

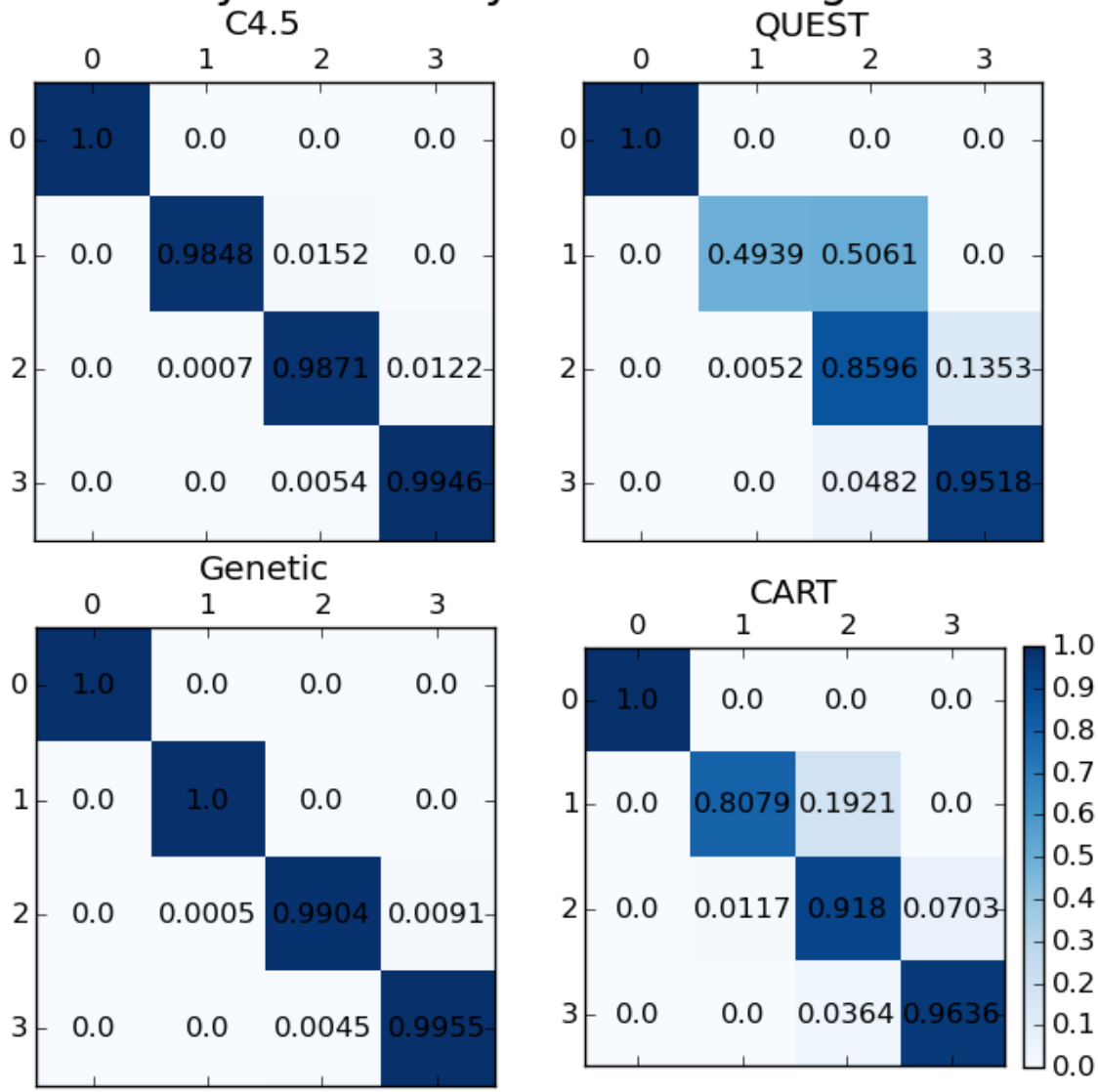
Evaluating our algorithm

5 datasets from UCI
optimal parameters, feature selection when needed and k-fold CV

Name	#Samples	#Disc	#Cont	#Class	Imbalance rate
Heart	270	7	6	2	0.058
Car	1728	6	0	4	0.225
Iris	150	0	4	3	0
Shuttle	14500	0	9	7	0.18308
Nursery	12960	8	0	5	0.1498

Dataset	Folds	C4.5	CART	QUEST	Genetic
Heart disease	5	**0.8067**	0.7844	0.7844	**0.8067**
	10	**0.8104**	0.7732	0.7881	0.7993
Iris	3	0.9533	0.9467	0.9467	**0.96**
	5	0.9467	0.9333	0.9467	**0.9533**
Cars	3	**0.9722**	0.9693	0.9229	0.9693
	5	0.9711	0.9682	0.9241	**0.9786**
	10	0.9756	0.9751	0.9265	**0.9803**
Shuttle	3	0.9987	0.9983	0.9964	**0.9988**
	5	0.9986	0.9981	0.9962	**0.9988**
	10	0.9990	0.9987	0.9941	**0.9992**
Nursery	3	0.9890	0.9431	0.9147	**0.9914**
	5	0.9918	0.9498	0.9251	**0.9958**
	10	0.9937	0.9568	0.9259	**0.9954**

Accuracy on nursery dataset using 10 folds

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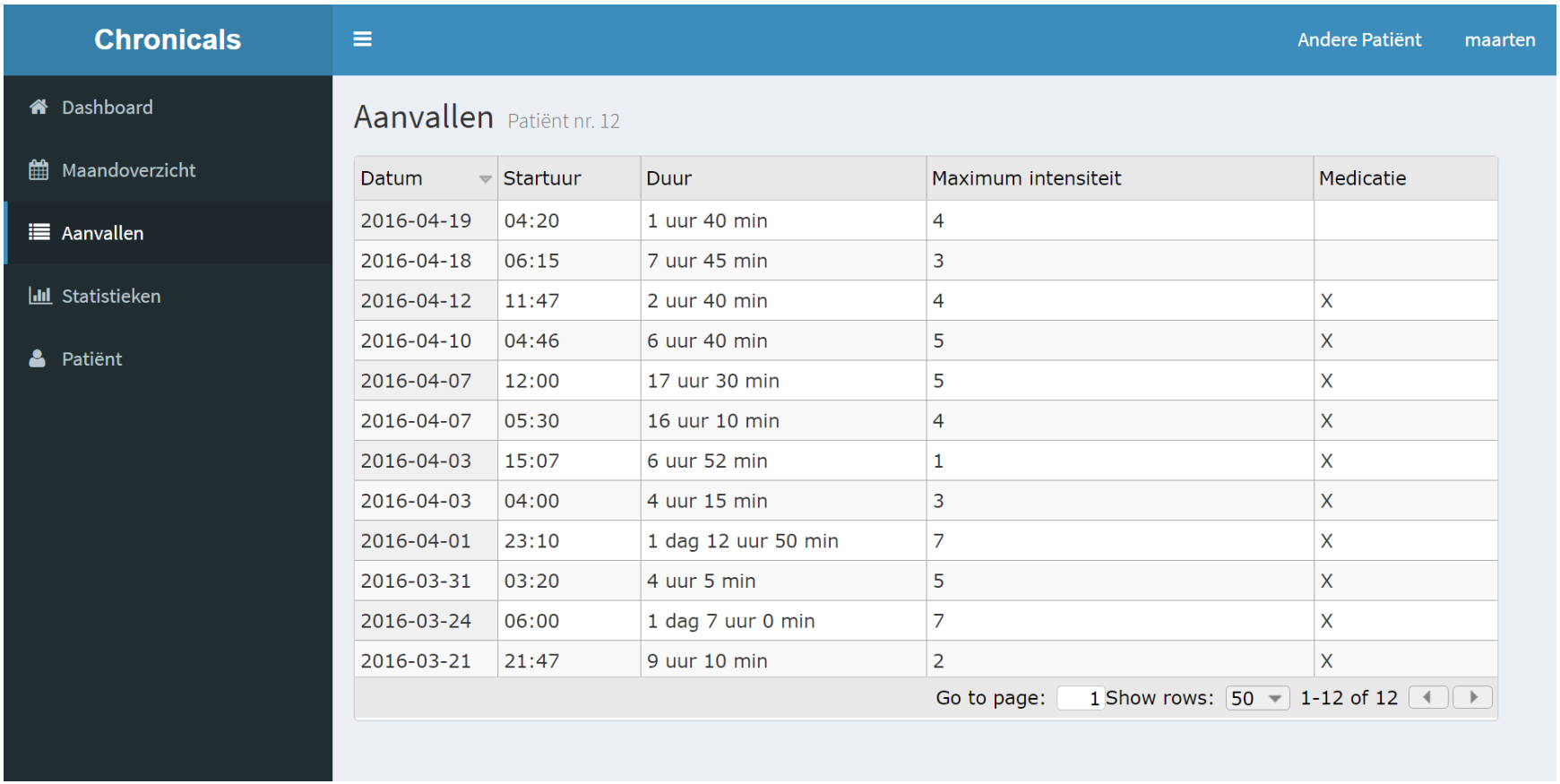
Doctor Dashboard

Maarten Vanden Berghe



Doctor Dashboard

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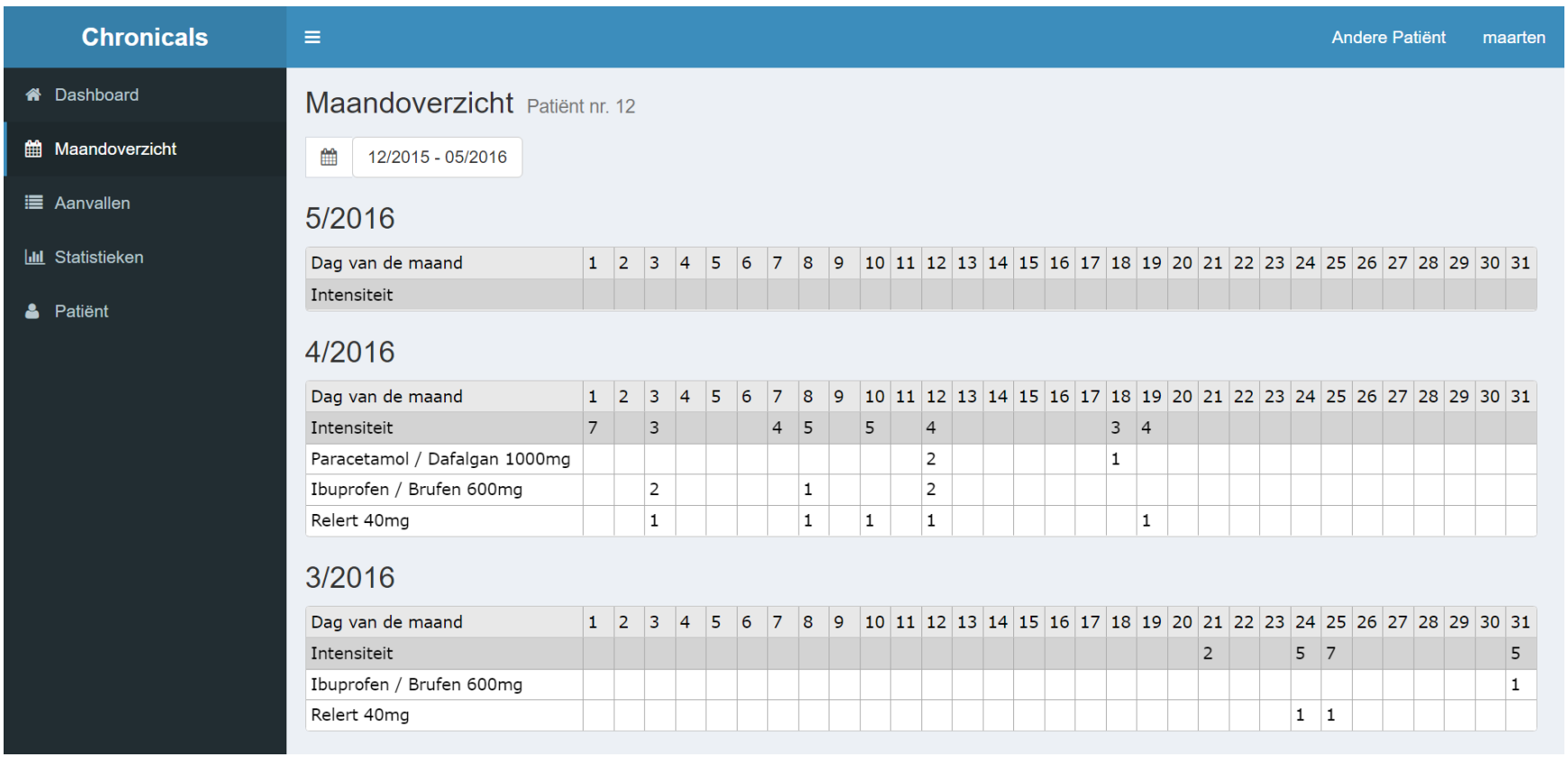


5/2016

Dag van de maand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Intensiteit																															

4/2016

Dag van de maand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Intensiteit	7		3				4	5		5		4						3	4												
Paracetamol / Dafalgan 1000mg												2						1													
Ibuprofen / Brufen 600mg			2					1				2																			
Relert 40mg			1					1		1		1							1												

3/2016

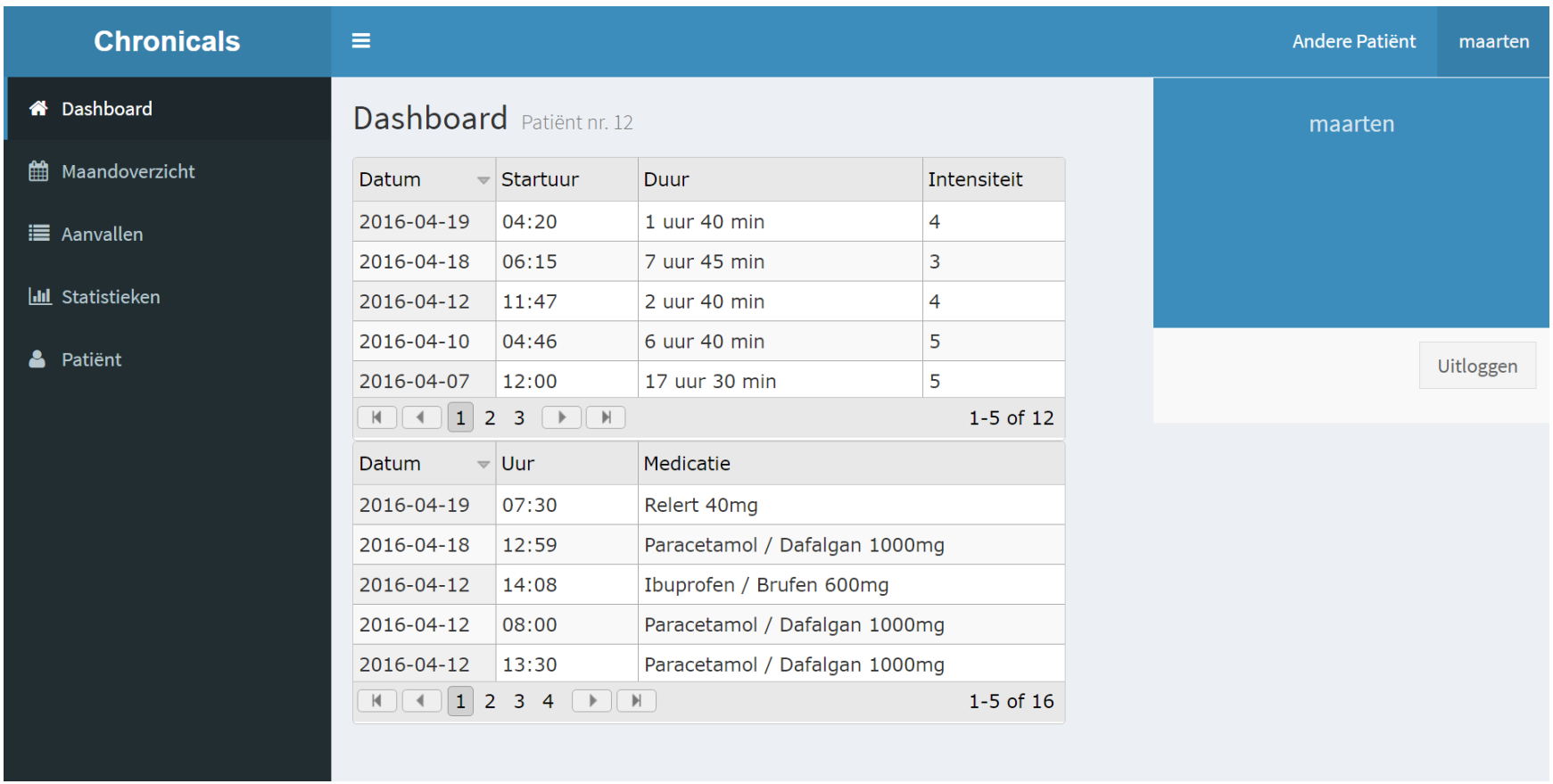
Dag van de maand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Intensiteit																					2			5	7						5
Ibuprofen / Brufen 600mg																															1
Relert 40mg																								1	1						

Doctor Dashboard

Maarten Vanden Berghe

Doctor Dashboard

Maarten Vanden Berghe



Bedankt

Bedank voor uw aandacht

No written word,
No spoken plea,
Can teach the youth what they should be,
Nor all the books on all the shelves,
It's what the teachers are themselves

Intro

Platform requirements

Mobile application

Backend and data exposure

Genetic merging of DT's

Visualization

Conclusion & future work