

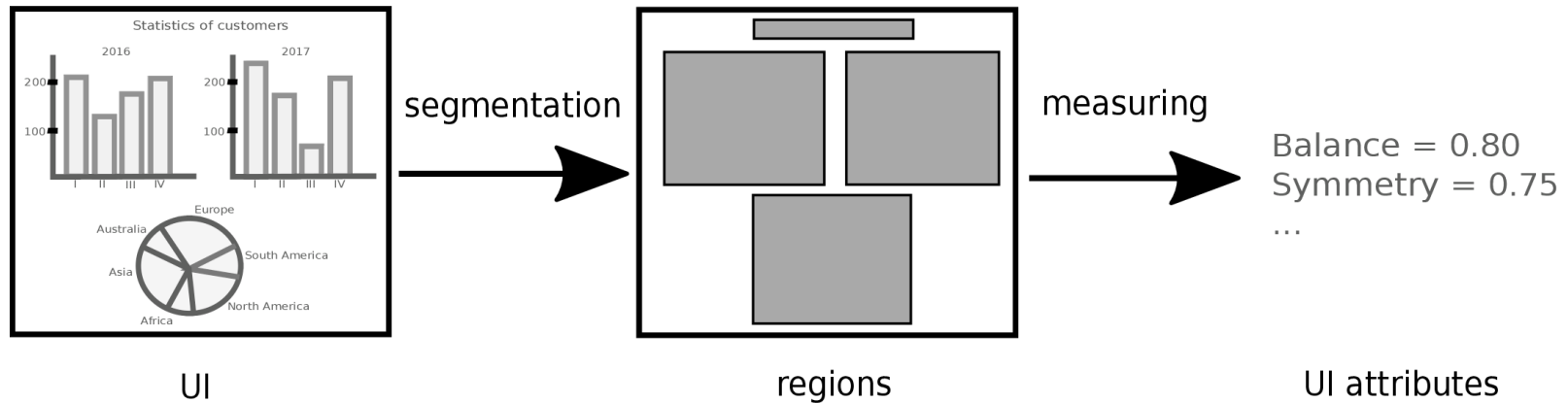
Segmentation of Dashboard Screen Images: Preparation of Inputs for Object-based Metrics of UI Quality

Jiří Hynek and Tomáš Hruška
Brno University of Technology, Faculty of Information Technology
Božetěchova 1/2, 612 66 Brno - Královo Pole
ihynek@fit.vut.cz



26.02.2019

Design a method for automatic segmentation of dashboards



Input = bitmap (UI screenshot)

Output = regions

- rectangle boundaries of visually dominant objects
- used for analysis of UI (quality, usability, ...)

Background

- tool for a **single screen** data visualization
- presents **the most important information**
- user can monitor the information **at a glance**
- helps to **achieve goals**

S. Few, 2006

- Malik S. (2005): Enterprise Dashboards, Wiley
- Few S. (2006): Information Dashboard Design, O'Reilly
- Eckerson W. (2006): Performance Dashboards, Wiley
- Wexler S., Shaffer J., Cotgreave A. (2017):
The Big Book of Dashboards, Wiley.

Top Stories - Google News

- As it happened: Philippines typhoon disaster (BBC News)
- Heavy smog hits north China city, flights canceled (New York Daily News)
- Enrollment could be lower than 100000 Hagan circulates Obamacare ... (Politico)
- After snowy morning commute, the day turns sunny, cold (Boston.com)

Current Location
London, England: 3:54 PM
Washington, DC: 10:54 AM

Sydney, Australia
63°

Today 79° 59°
Wednesday 79° 59°
Thursday 71° 61°
Friday 69° 59°

Server Status

Server	Ping
spiderstrategies.com	60ms
How to spike your hair	Down
github.com	232ms
thedash.com	302ms
atp.fm	662ms

People on thedash.com
17
30 day max: 25

Klipfolio.com

CIO Dashboard (As of December 19, 2004, 3:35 PM)

System Availability (Last 30 days)

System	Availability %
Network	98.5%
ERP	97.9%
Data Warehouse	93.2%
Web Site	98.5%
Email	100.0%
HR	96.7%
Problem Tracking	94.7%

Key Non-System Metrics

Metric	% of Target	Actual
Expenses YTD	98.5%	\$2,458.5K
Customer Satisfaction	Level 1 Problems	3.25 of 4

Major Project Milestones

Project	Milestone	Due Date	Days Until/Past Due
ERP Upgrade	Full system test	01/10/06	-22
Add services data to DW	ETL coding	12/15/05	-3
Upgrade mainframe OS	Prepare plan	12/23/05	4
Disaster recovery site	Install hardware	01/08/06	20
Budgeting system	Hire team	12/06/05	-13
Web site face-lift	Move into production	01/05/05	17

5 Top Projects in the Queue (Sorted by priority)

Project	Status	Funding Approved	Sched. Start
1 Professional services module	Pending available staff	X	05/10/06
2 Upgrade MS Office	Cost-benefit analysis		02/15/06
3 Failover for ERP	Preparing proposal		06/02/06
4 Upgrade data warehouse HW	Evaluating options	X	04/15/06
5 Executive dashboard	Vendor assessment		07/01/06

Critical Events (Next 14 Days)

Event	Group	Responsible	Date
Full system maintenance outage from 9-11 PM		G. Jones	12/21/05
Present hardware upgrade proposal to CEO		Self/M. Smith	12/22/05
Tom visiting from Asia office		Self	12/23/05
Prepare quarterly financial for public announcement		Self	01/04/06
Present revised information strategy to steering comm.		J. Kane	01/05/05

S. Few

Further services:
Sisense.com, Datapine.com,
ClicData.com, Plot.ly, ...

Command Center

Social Media Followers

- Facebook: 26,472 Likes
- YouTube: 13,911 Subscribers
- Instagram: 6,524 Followers
- Google+: 5,093 Circled by
- Twitter: 45,322 Followers
- LinkedIn: 1,765 Followers

Wistia Video Stats

- Metrics Driven Design Management: 563 Play Count, 75% Engagement, 49% Play Rate

CallRail Today's Average Call Duration
10m:8s (Based on 19 calls)

Alexa Page Views per User (Last 30 days)

Facebook Demographics

Web Site
Kingdom & Google Analytics: Load Time vs Response Time

Advertising & Promotion
Expenses/Traffic: \$16,839 (13.75% A vs \$13,000 Target)

Session Traffic
280,430 (29.44% A vs 250,000 Target)

Quickbooks & Salesforce: CAC (Last 30 Days)
\$15,085 (CAC Index: -29.99% vs \$21,500 Target)

Leads (This Month)
10,753 (8,912 Last Month)

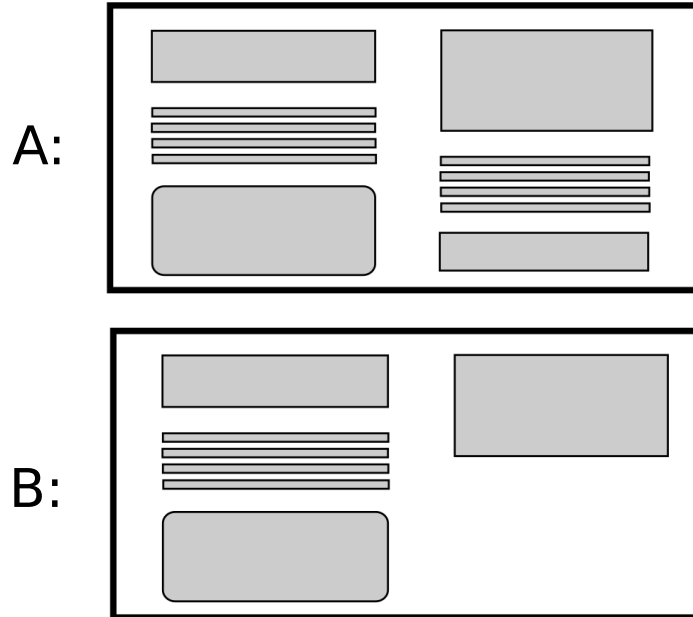
Salesforce Accounts by Country

TheDash.com

- quantitative measuring of UI characteristics
- avoid design problems during early design phase
- decrease “some” time and resources of user testing

Object-based metrics: **Balance**

by **D. C. L. Ngo, L. S. Teo , and J. G. Byrne** (2003)



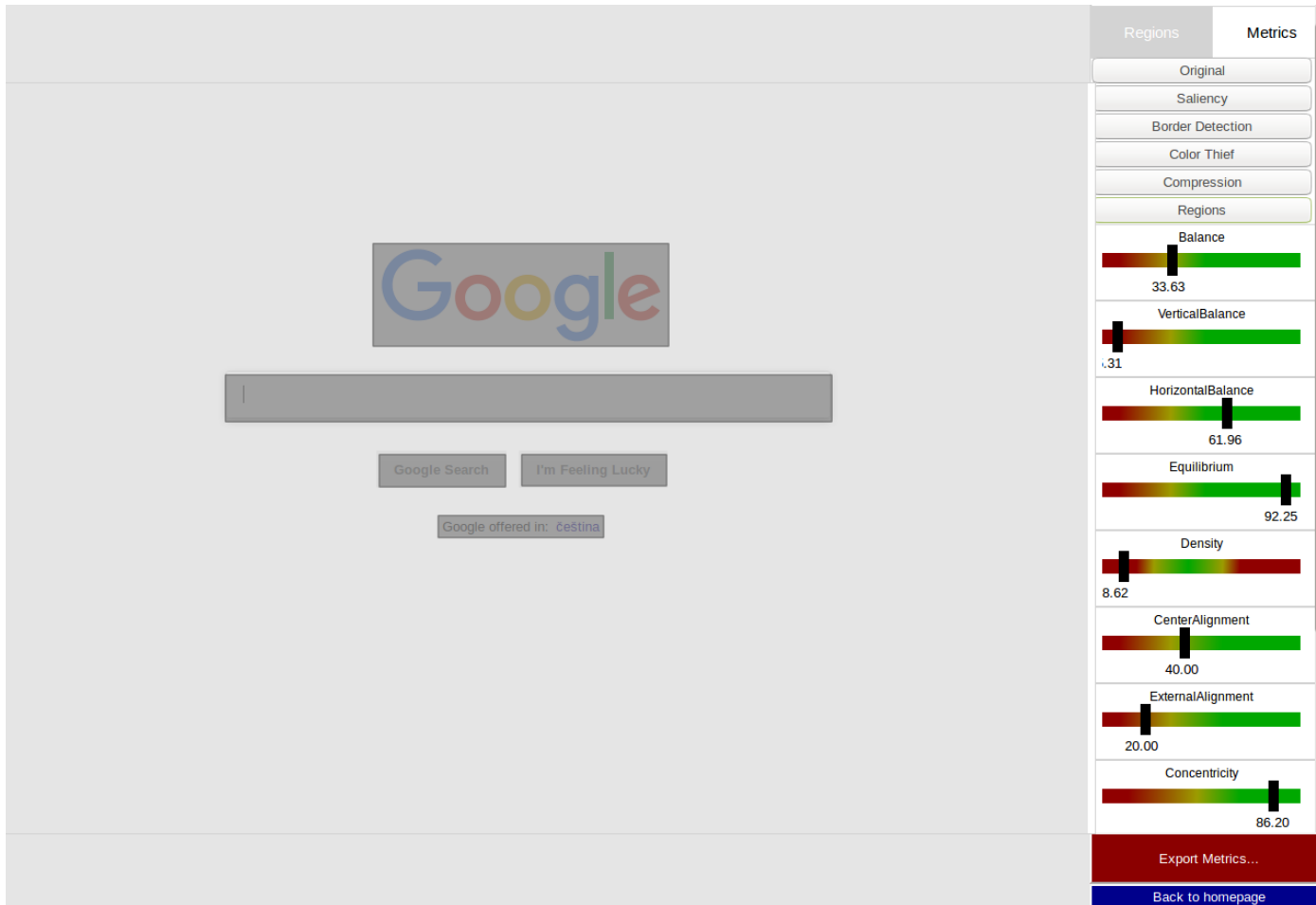
$$BM = 1 - \frac{|BM_{\text{vertical}}| + |BM_{\text{horizontal}}|}{2} \in [0, 1]$$

$$BM_{\text{vertical}} = \frac{w_L - w_R}{\max(|w_L|, |w_R|)}$$

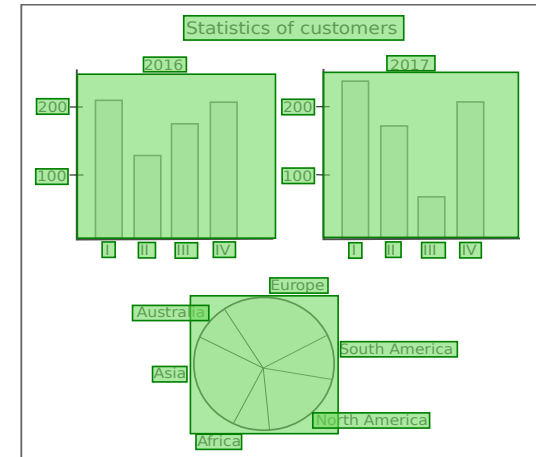
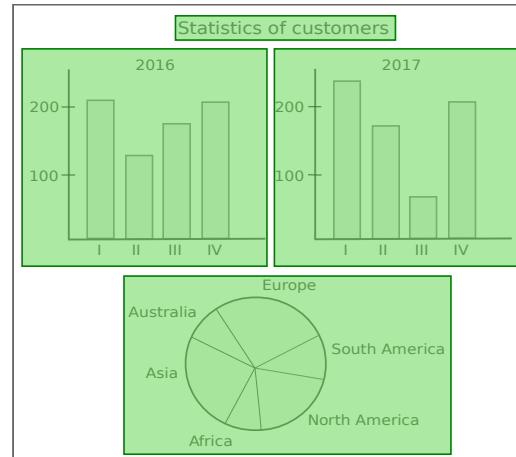
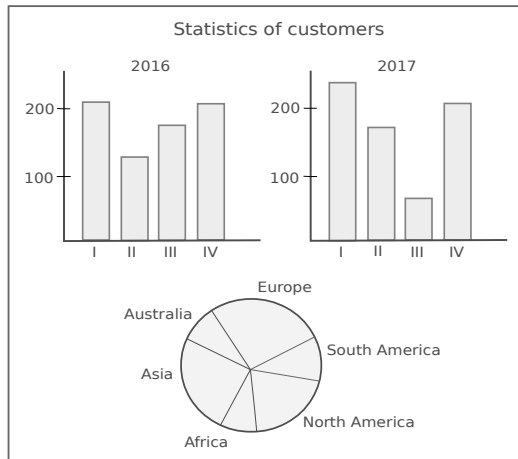
$$BM_{\text{horizontal}} = \frac{w_T - w_B}{\max(|w_T|, |w_B|)}$$

$$w_j = \sum_i^{n_j} a_{ij} d_{ij} \quad j = L, R, T, B$$

- **QUESTIM: Quality Estimator Tool using Metrics**
by **M. Zen and J. Vanderdonckt** (2014).
<http://questimapp.appspot.com>



What are the object regions?



- 1) manual selection by users
- 2) parsing the UI source code (HTML+CSS+Javascript, ... ?)
- 3) segmentation of UI screenshot

Gestalt laws, subjective perception of users,

Study of Visual Perception

- **251** users, **130** dashboards
- every user **20** samples (every dashboard ~ **39** users)
- Java application for selection visually dominant regions

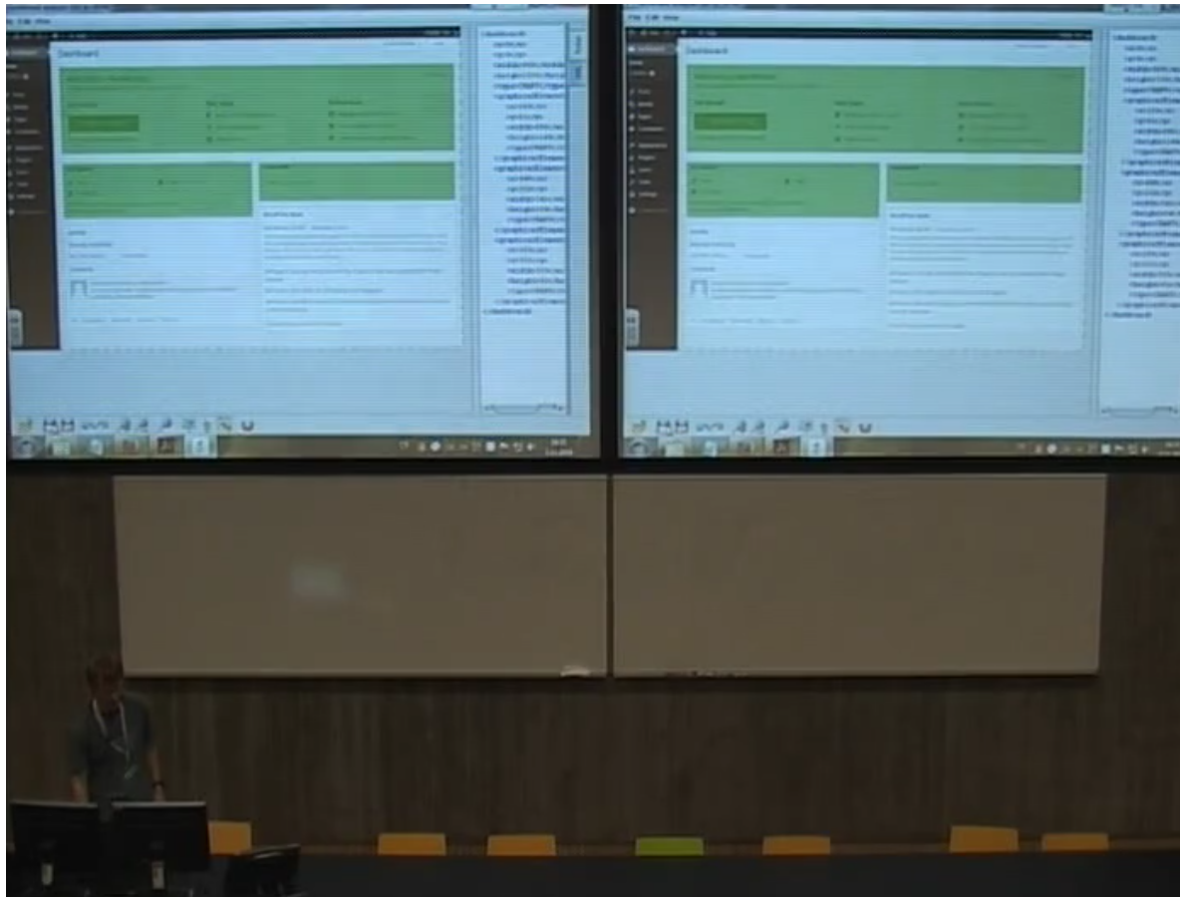
The screenshot shows a 'Dashboard analyzer' application window. The main dashboard area displays several key metrics and charts:

- Deposits:** A green box showing '\$790.26' with 'Upcoming Deposits' and '\$1,473.56 Last Deposit' below it.
- Gross Sales:** A grey box showing '\$1,142.62' with '+ 7.26% From Last Week' and '+ 4.18% From 6 Months Ago' below it, and '58 Transactions' at the bottom.
- Payment Methods:** A vertical bar chart showing 'CREDIT', 'CASH', and 'OTHER' categories.
- Top Items by Sales:** A table listing items like 'Three Piece Table...', 'Wooden Bowls', 'Throw Pillows', 'Bath Towels', and 'Bath Soaps' with their respective sales values and counts.
- Top Categories by Sales:** A donut chart and a list of categories including 'Bathroom', 'Bedroom', 'Kitchen', 'Living Room', and 'Other'.

On the right side of the application, there is a code editor showing XML code for the dashboard structure:

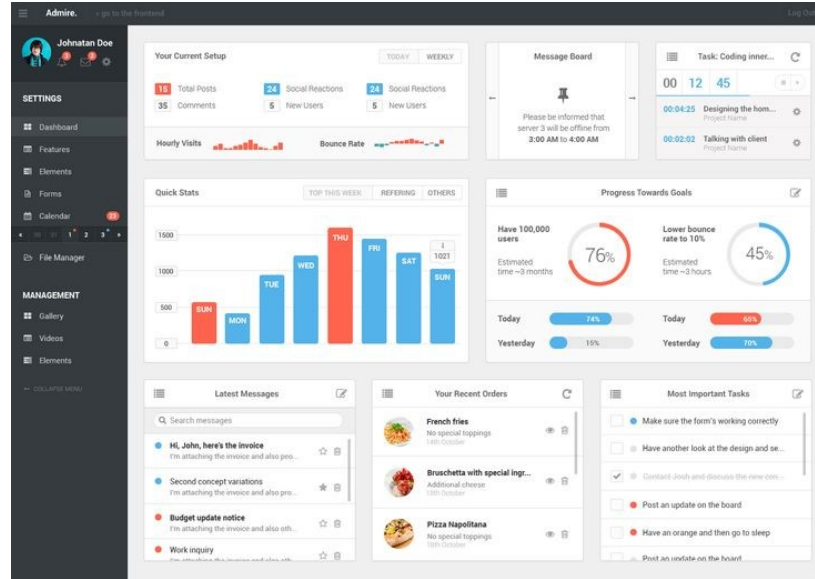
```
<dashboard>
  <x>0</x>
  <y>0</y>
  <width>1440</width>
  <height>900</height>
  <type>CHART</type>
  <graphicalElement>
    <x>268</x>
    <y>146</y>
    <width>370</width>
    <height>348</height>
    <type>CHART</type>
  </graphicalElement>
</dashboard>
```

- IT students at Brno University of Technology (~20 years old)
- familiarized with the software, dashboards, Gestalt laws and the task (2 hours lecture)

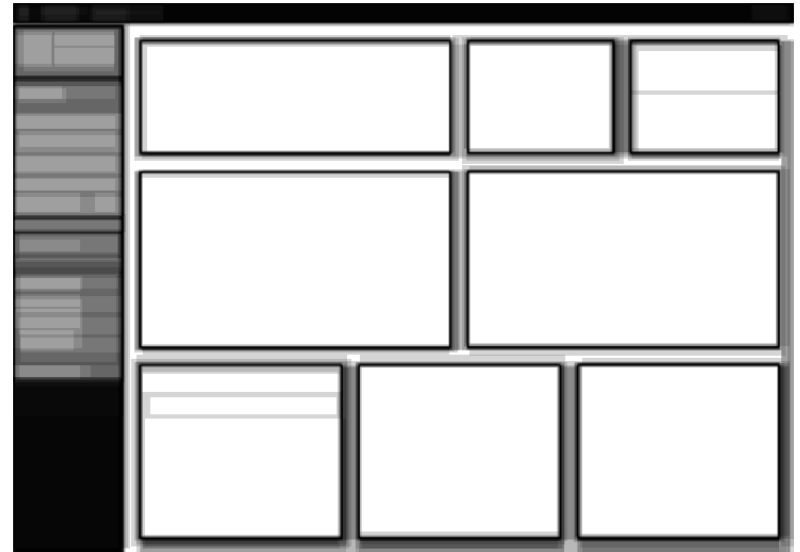
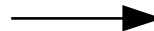
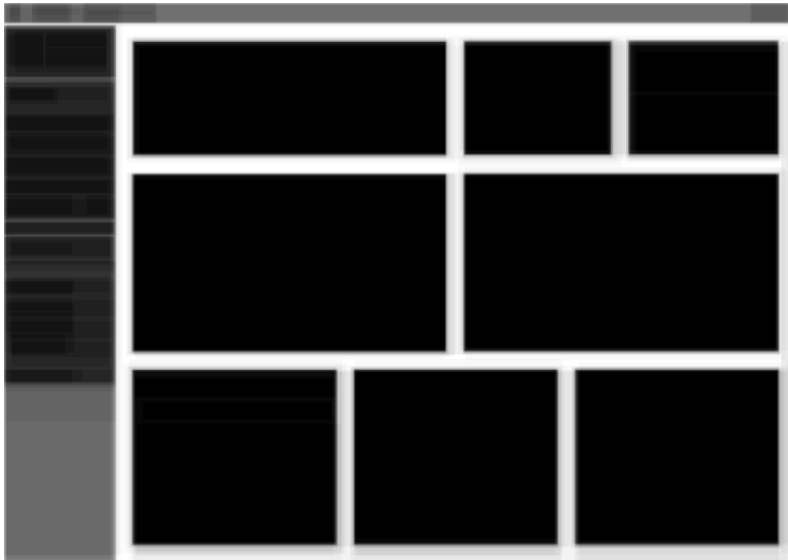


1.

n users

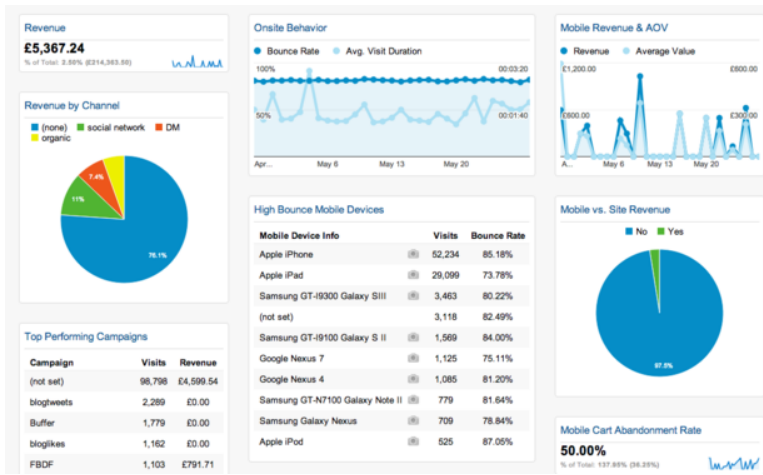


2. Average description of regions (Heatmap)

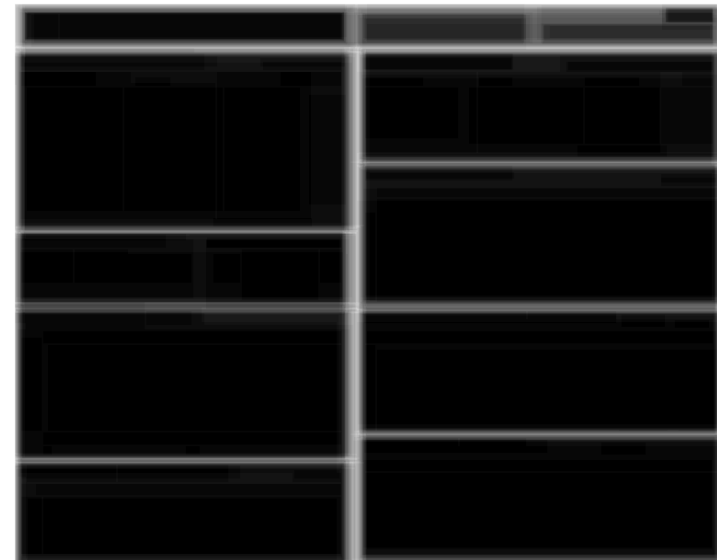
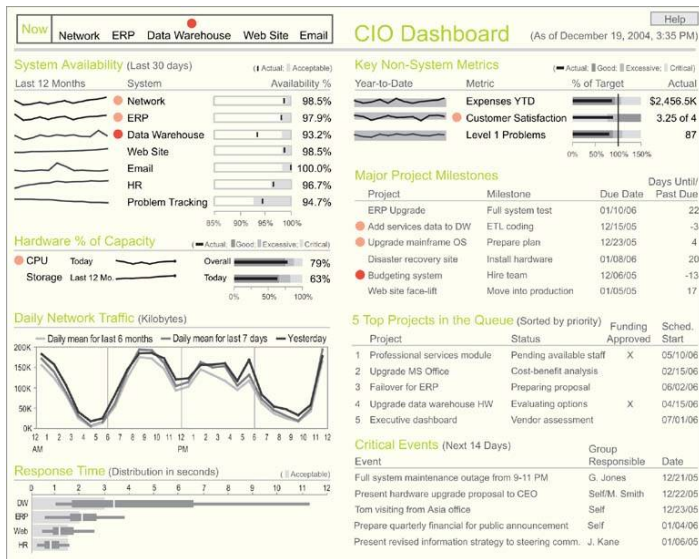


3. Perception ambiguity (Binary Entropy)

1. Gestalt law of Enclosure

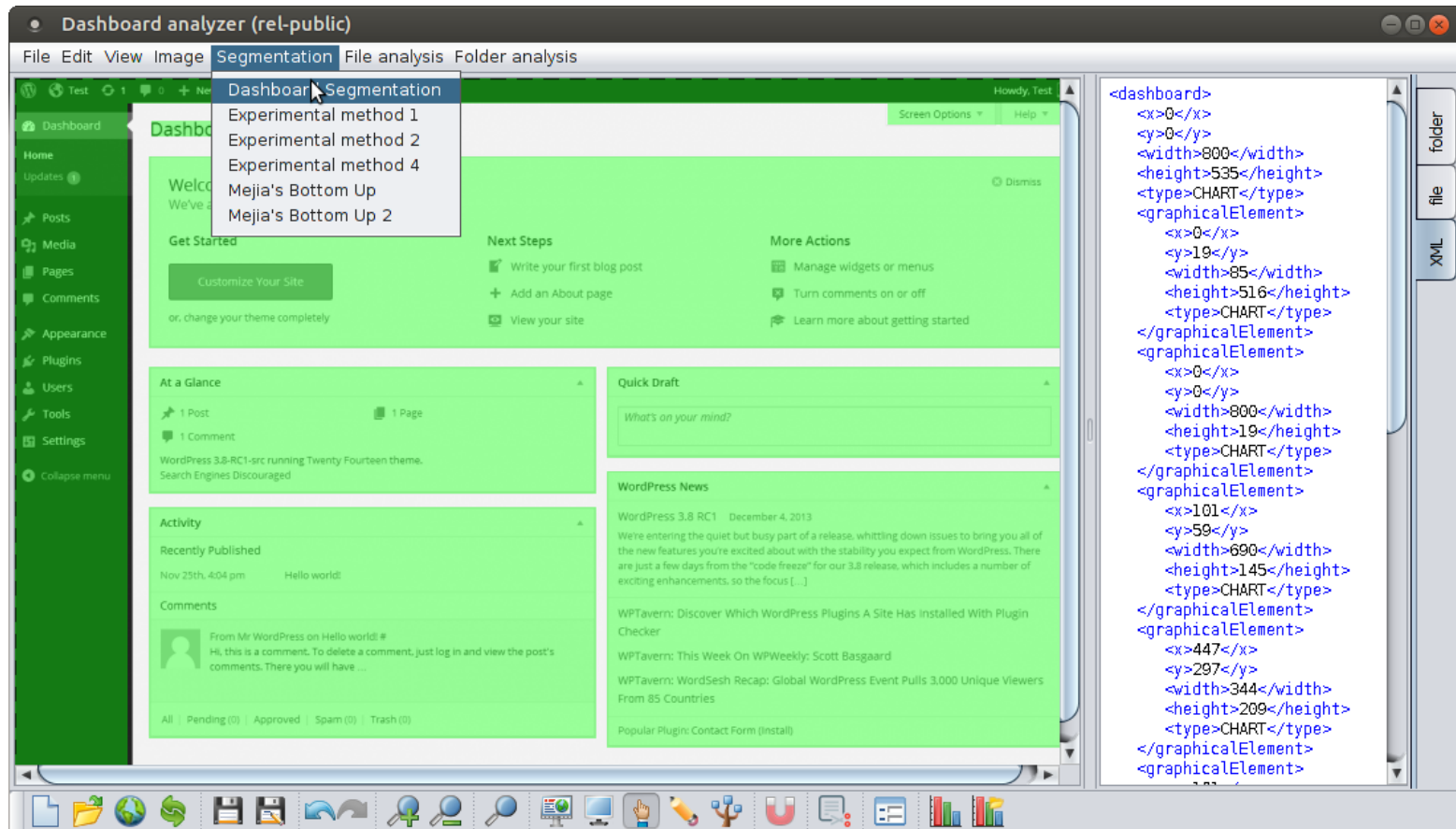


2. Gestalt law of Proximity and Closure

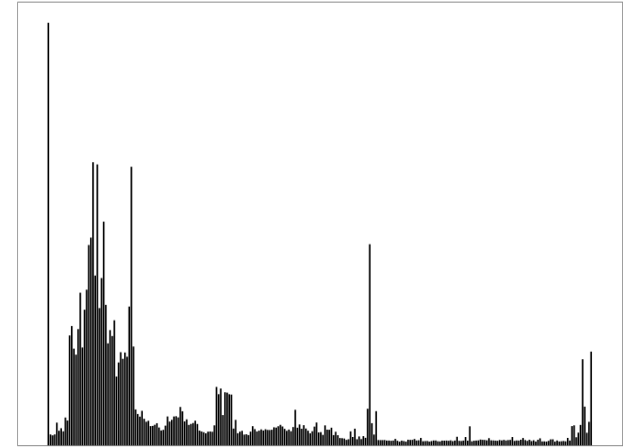


Method for Segmentation of Dashboards

- Method integrated in **Dashboard Analyzer**
- fit.vut.cz/~ihynek/dashboards/visigrapp-2019
- github.com/Jirka/dash



1) 24-bit RGB → 8-bit Grayscale color space (256 colors)

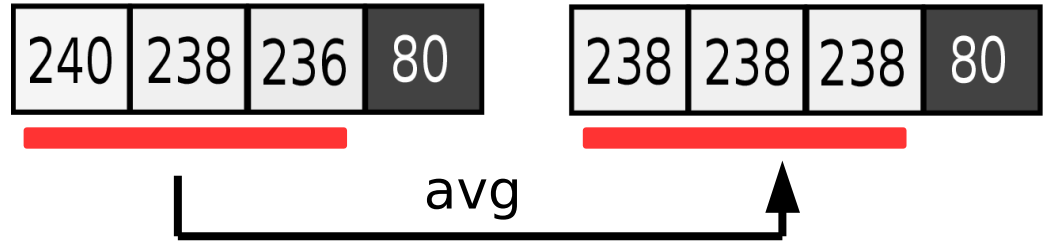


2) Remove color gradients

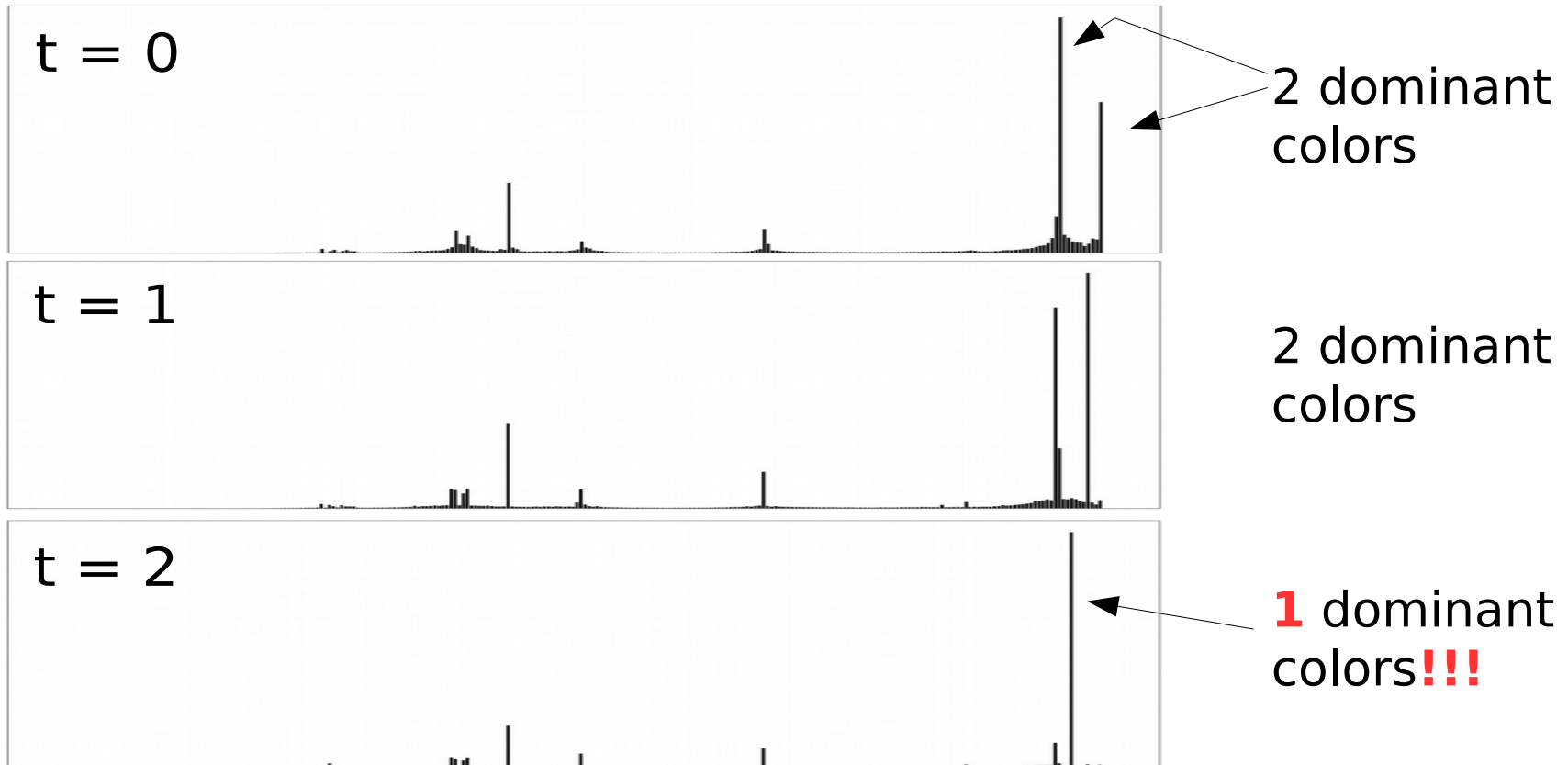
3) Posterization to [4-6]-bit Grayscale color space



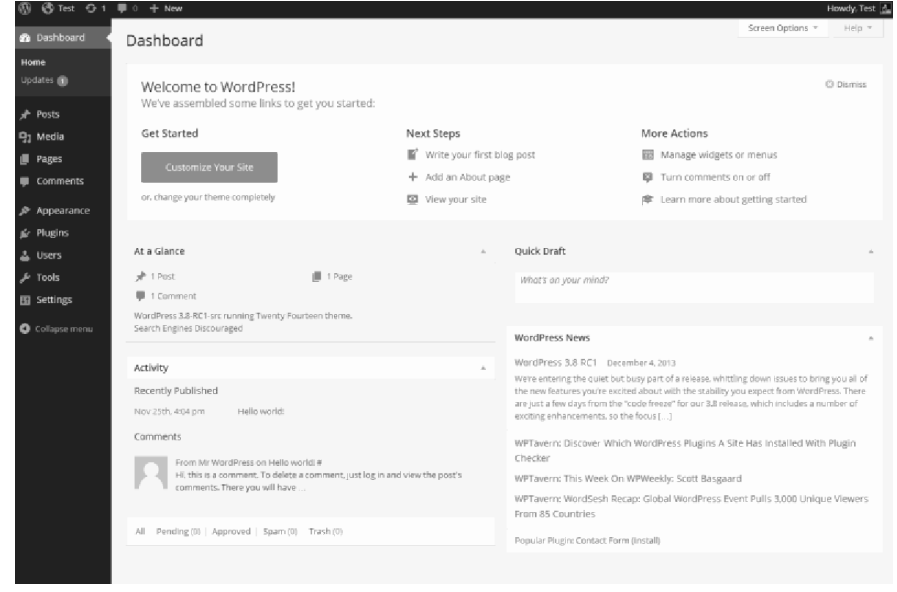
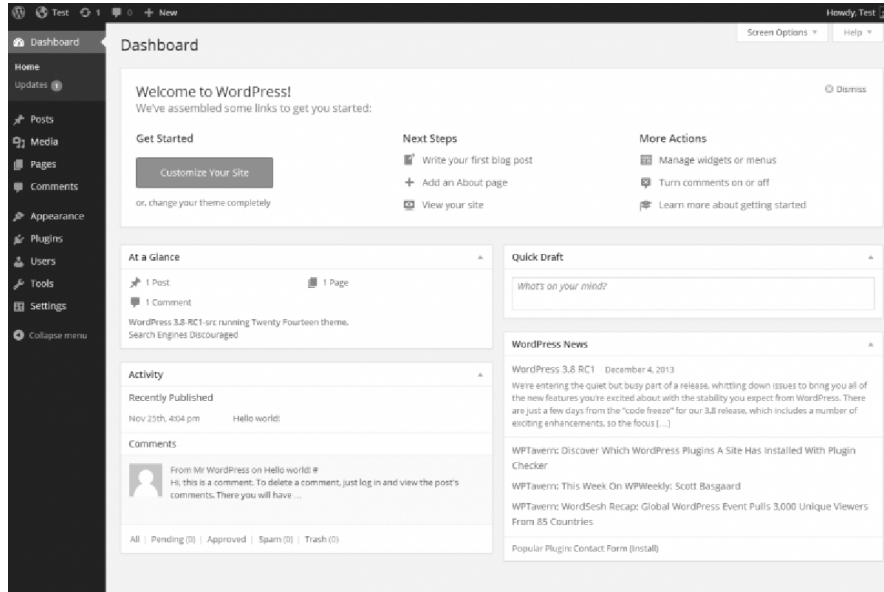
Searching clr. gradients:
flood-fill-based algorithm



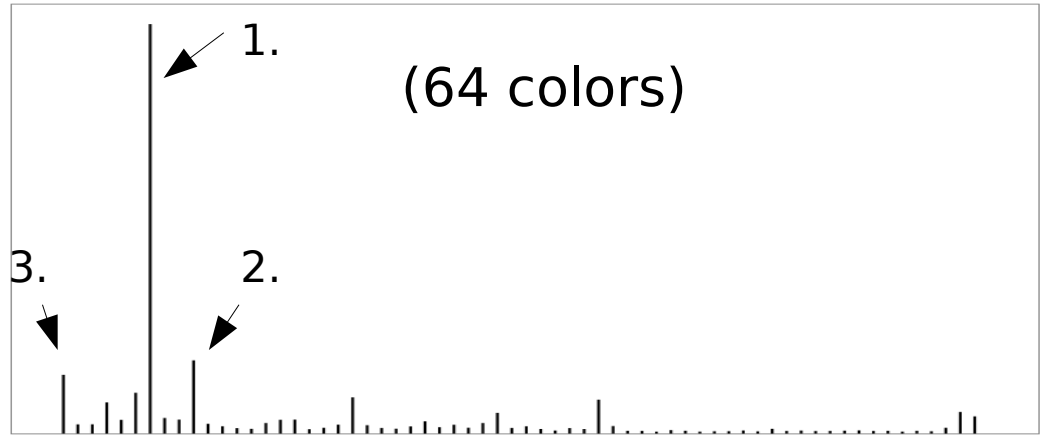
Selecting threshold:



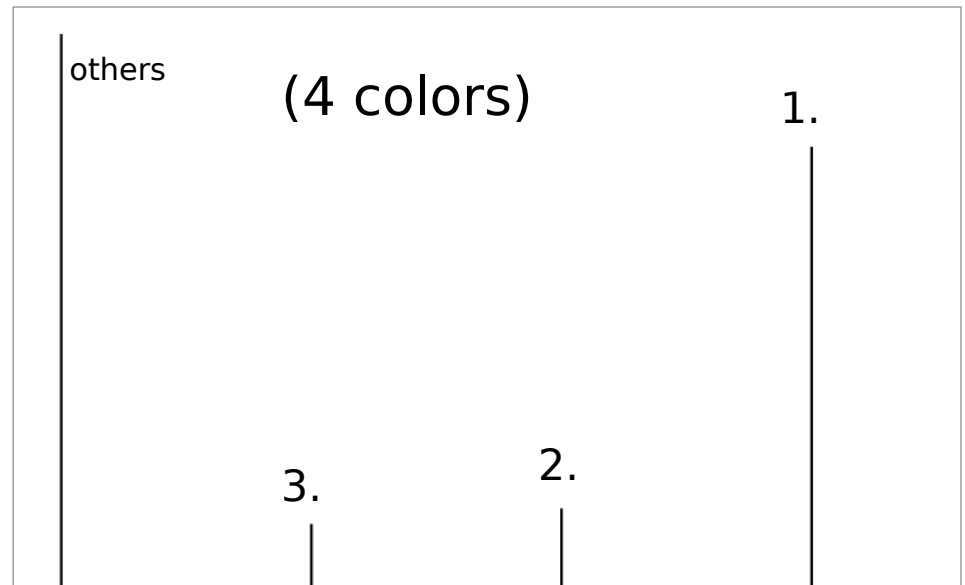
Phase 1/7: Image Preprocessing



Phase 2/7: Selection of Color Layers



Select [2-10] dominant colors:



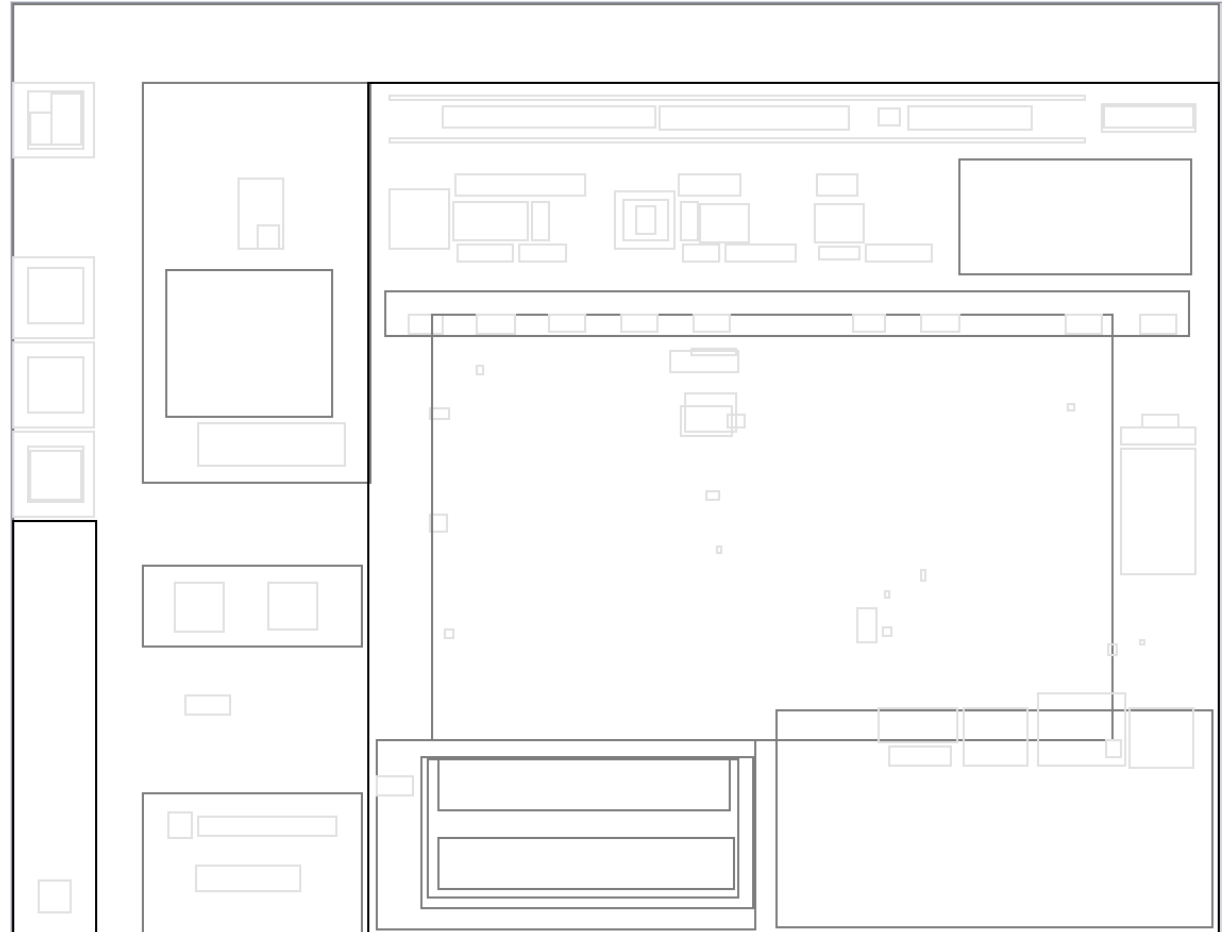


Find boundaries of the “same-color” pixel areas (*Gestalt law of closure*):

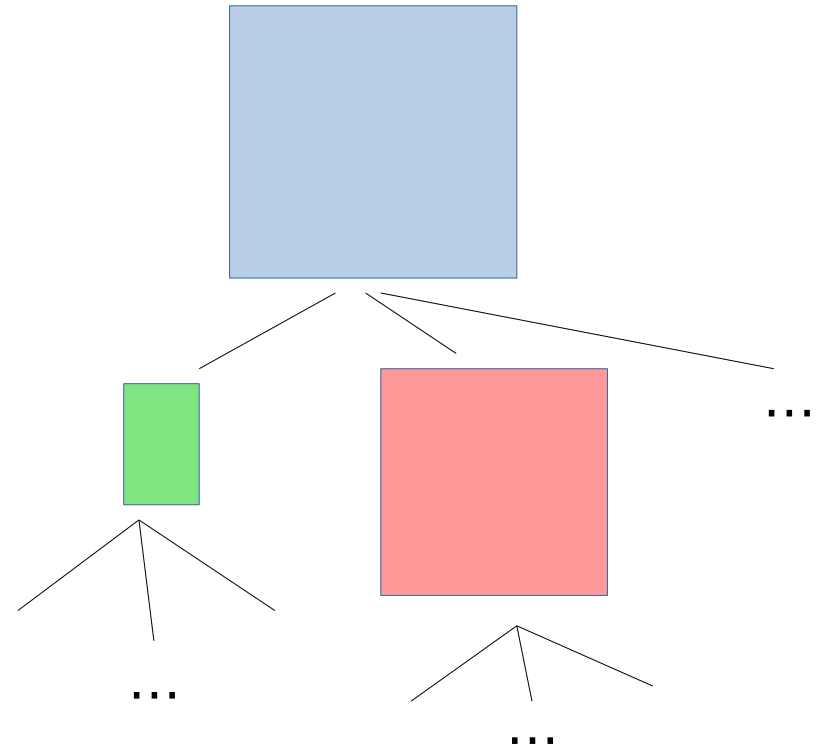
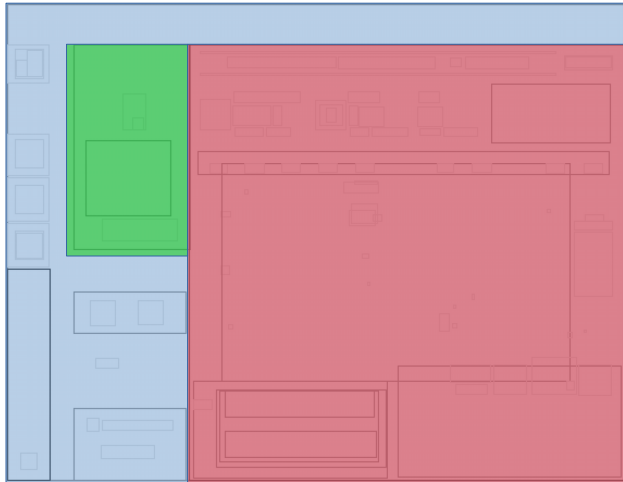
Using
Flood-fill-based
Algorithm

Remember

- color
- share of pixels in boundary

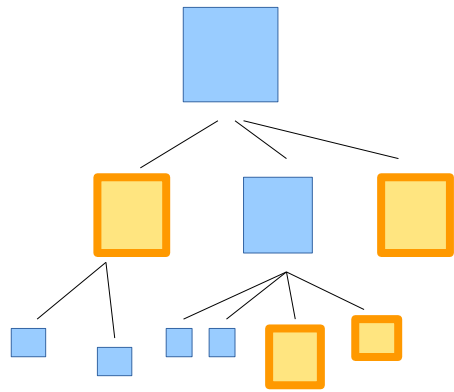


Building the tree of regions:



Process r1:

```
if r1 is in r2:  
    attach r1 to r2  
if r2 is in r1:  
    attach r1 to r2.parent  
    reattach r2 to r1  
if r1 intersects r2 or:  
    attach r1 to r2. parent
```



Searching dominant regions
Gestalt law of enclosure



1. sidebars

2. size of regions

~0.3-0.7 of area

has tiny children

...

3. type of regions

background color

...

Analysis of regions intersections

Regions within regions

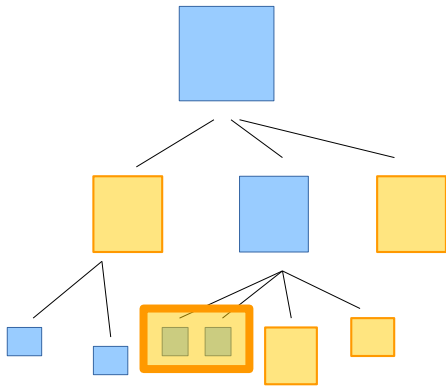
→ remove smaller

>0.33 of regions area, ...

→ join regions

Else ignore





Analysis of remaining area
Gestalt law of proximity



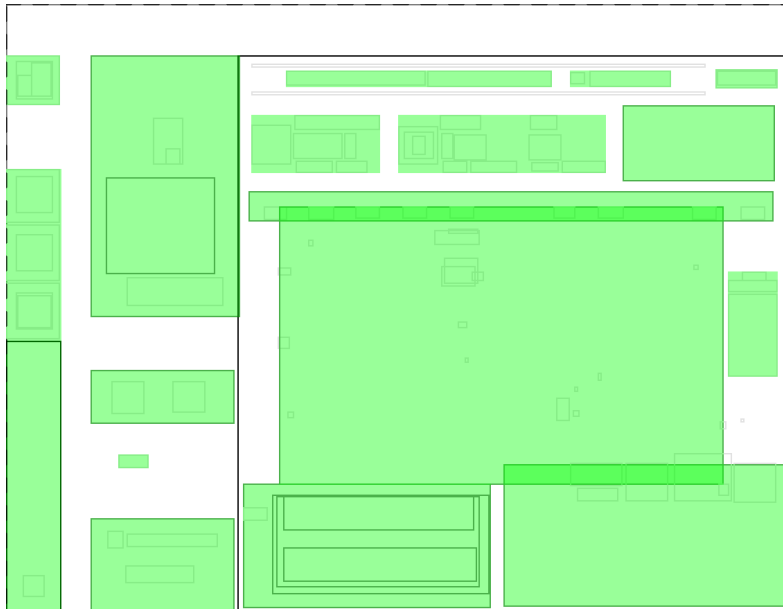
- grouping of remaining regions
- avoid new intersections

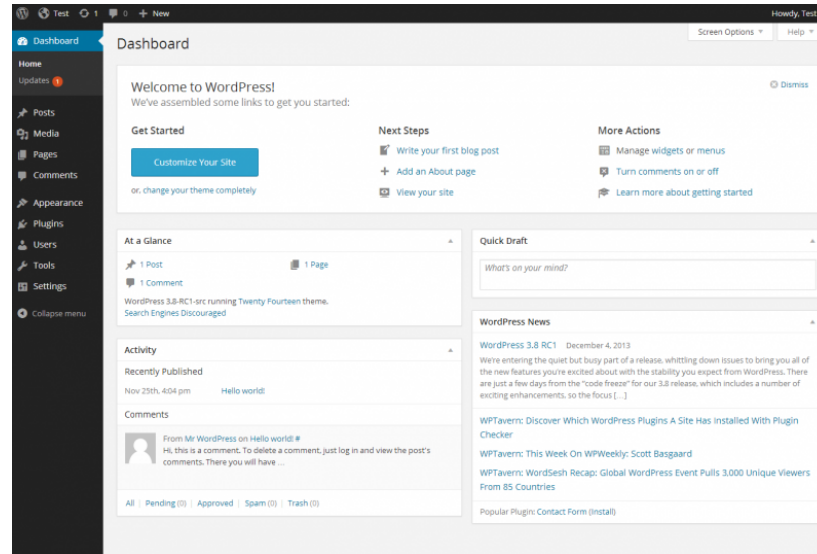
Evaluation



alg.

avg.

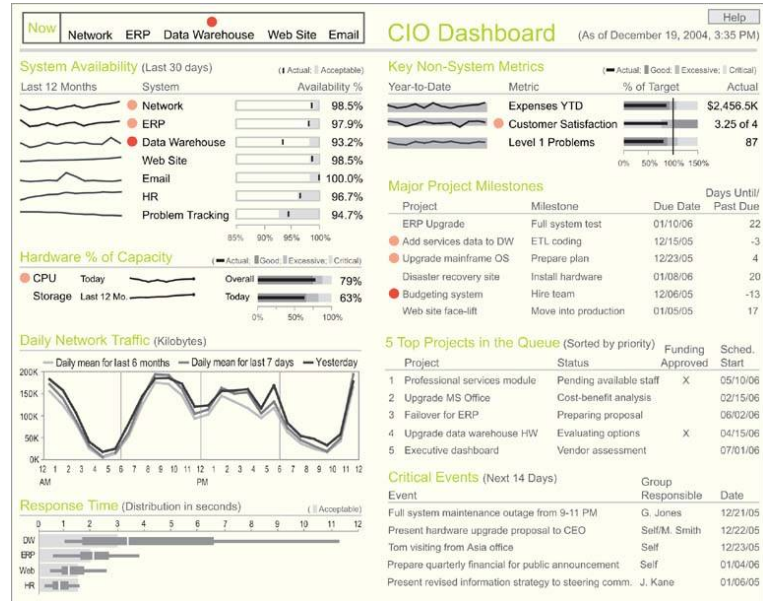




alg.

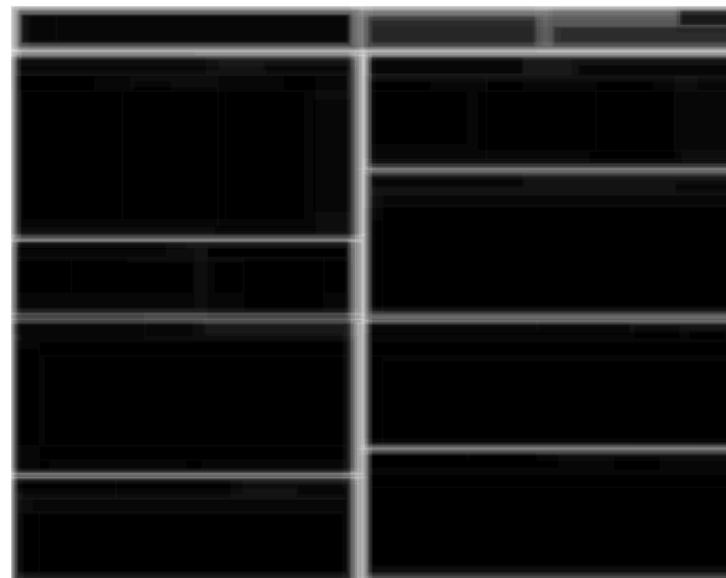
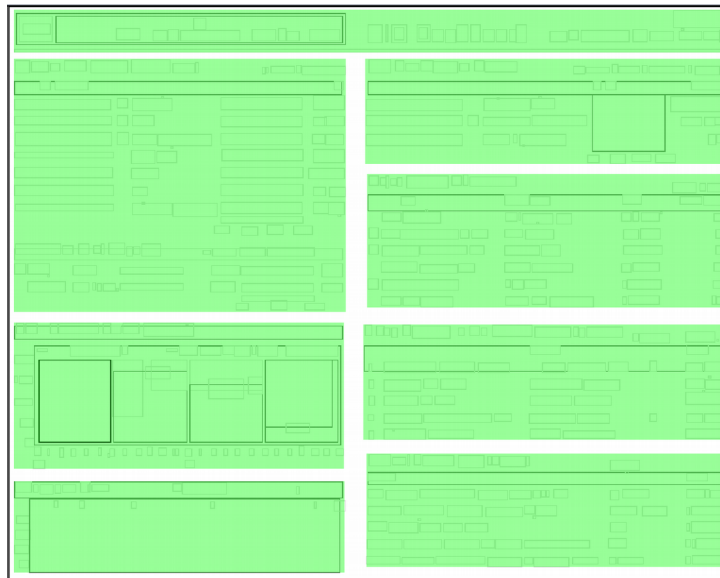
avg.





alg.

avg.



| avg. - **user** u |

| avg. - **alg.** |

For one pixel:

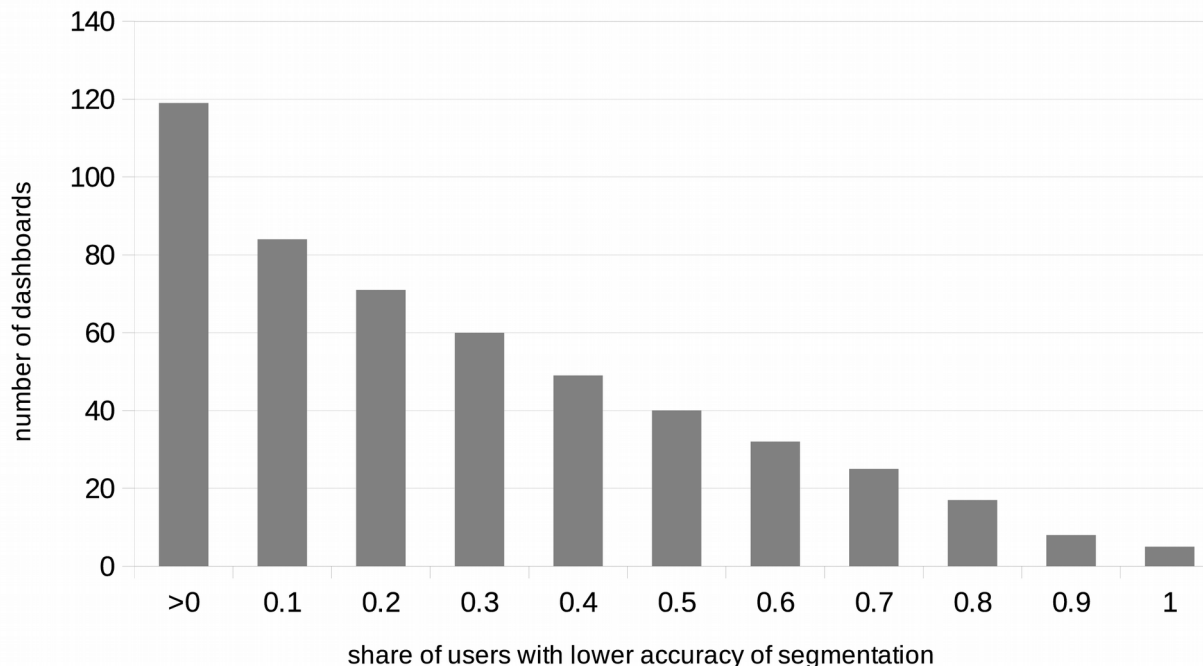
$$\delta_i^{(u)} = | p_i - v_i^{(u)} |$$

$$\delta_i^{(\text{alg})} = | p_i - v_i^{(\text{alg})} |$$

For all n pixel:

$$\delta_d^{(u)} = \frac{\sum_{i=0}^n \delta_i^{(u)}}{n}$$

$$\delta_d^{(\text{alg})} = \frac{\sum_{i=0}^n \delta_i^{(\text{alg})}}{n}$$



119 of 130 dashboards segmented *“better”* ($\delta_d^{(\text{alg})} \leq \delta_d^{(u)}$) than at least one user

We measured values $BM \in \langle 0,1 \rangle$ for:

Users (on average)	alg.	 Users - alg.
$\mu(BM_{d1}^{(u)})$ $\sigma(BM_{d1}^{(u)})$	$BM_{d1}^{(alg)}$	$\delta_{d1}^{(alg,users)}$
$\mu(BM_{d2}^{(u)})$ $\sigma(BM_{d2}^{(u)})$	$BM_{d2}^{(alg)}$	$\delta_{d2}^{(alg,users)}$
...
$\mu(BM_{d130}^{(u)})$ $\sigma(BM_{d1}^{(u)})$	$BM_{d130}^{(alg)}$	$\delta_{d130}^{(alg,users)}$

$$\mu(\sigma(BM^{(u)})) = 0.119$$

$$\mu(\delta^{(alg,users)}) = 0.1$$

$$(\sigma = 0.086)$$

Summary

- trained for 130 dashboard samples
- based on perception of selected users
- problems with lower resolutions of images

Future work

- further evaluations should be done
- improvement of image preprocessing
- improvements of heuristics

- fit.vut.cz/~ihynek/dashboards/visigrapp-2019
- github.com/Jirka/dash
- Hynek, J. and Hruška, T. (2018). Application of object-based metrics for recognition of well-designed dashboards. *International Journal of Human–Computer Interaction*, pages 1–13, Taylor & Francis.

Thank You For Your Attention !