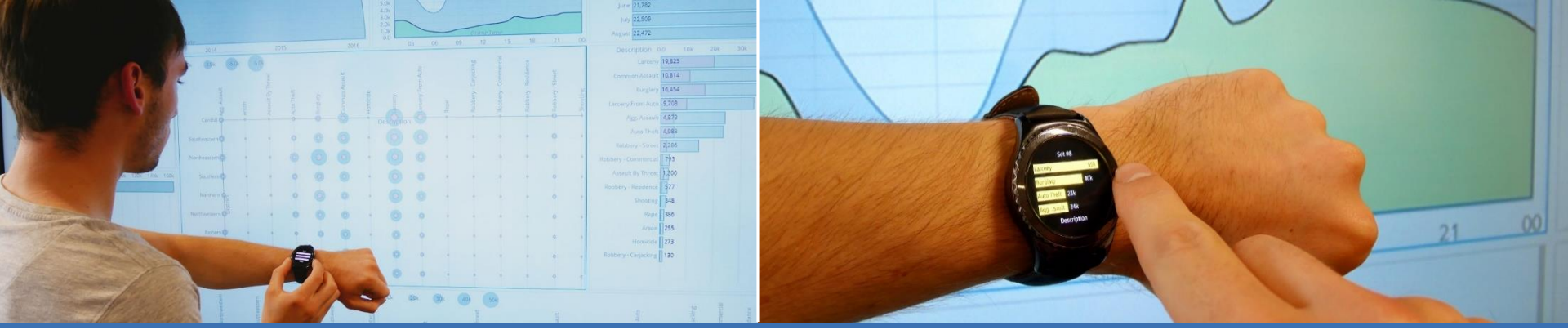


When David meets Goliath:
Combining Smartwatches with a Large Vertical Display for Visual Data Exploration

Tom Horak & Sriram **Karthik** Badam

Niklas Elmqvist, Raimund Dachselt

Awarded Honorable Mention at ACM CHI 2018
Montréal, QC, Canada

TECHNISCHE UNIVERSITÄT DRESDEN

INTERACTIVE MEDIA LAB DRESDEN

UNIVERSITY OF MARYLAND 18 56

HCIL


Promethean
ActivPanel
Crime
Crime
BALTIMORE
District
Northeastern 39,853
Southeastern 34,398
Central 29,366
Southern 28,354
Northern 27,690
Northwestern 24,986
Southwestern 22,632
Eastern 20,865
Weapon
None 65,799
Hands
Firearm 17,705
Other
Knife 8,730
WANTED
WANTED
WANTED
WANTED
WANTED

How to design cross-device interaction for smartwatch and large displays?

Multi-Display Environments (MDE) allow separating shared and private views

Hand-held devices can support spatially-aware interaction styles

But what about smartwatch + large display?

Combination is underexplored, especially for vertical displays and visual analysis

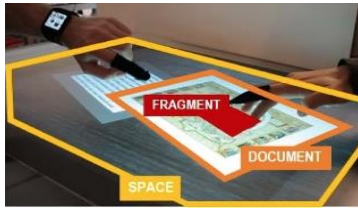
Badam et al. 2017: *Visfer*

McGrath et al. 2012: *Branch-merge-explore*

Kister et al. 2017: *GraSp*

Langner et al. 2018: *VisTiles*

Brudy et al. 2016: *CurationSpace*



Smartwatches feature multiple advantages: wearable, lightweight, non-intrusive, personal

The combination with a large display leads to specific roles

Large display
= primary display, public and shared

Smartwatch
= user-specific storage
= mediator altering system reactions
= remote control for distant interaction

We contribute a conceptual framework supporting users during visual exploration

Item Sets & Connective Areas
= *What & Where*

Cross-Device Interactions
= *How*

Vision:
Bridge Large Display and Smartwatch for Visual Analysis

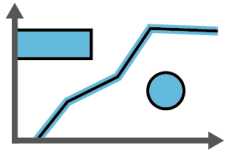
Item Sets are a collection of entities that are stored on a user's smartwatch

Two set types:

- data items (points of interest)
- configuration properties (settings of interest)

User-specific and stored as a list on the watch

Connective Areas (CA) provide contextual information about a user's intents



marks

create selections
from a visualization

canvas

access stored
sets of data items

axes

access available
axes properties

origin

access available
chart properties

Users follow a specific intent when interacting

Idea:
Providing suitable functionalities based on the Connective Area

Focusing a Connective Area by double-tap or hold

We propose a simple interaction workflow for data exploration

Pull

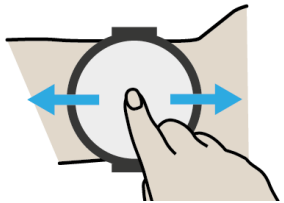
Preview

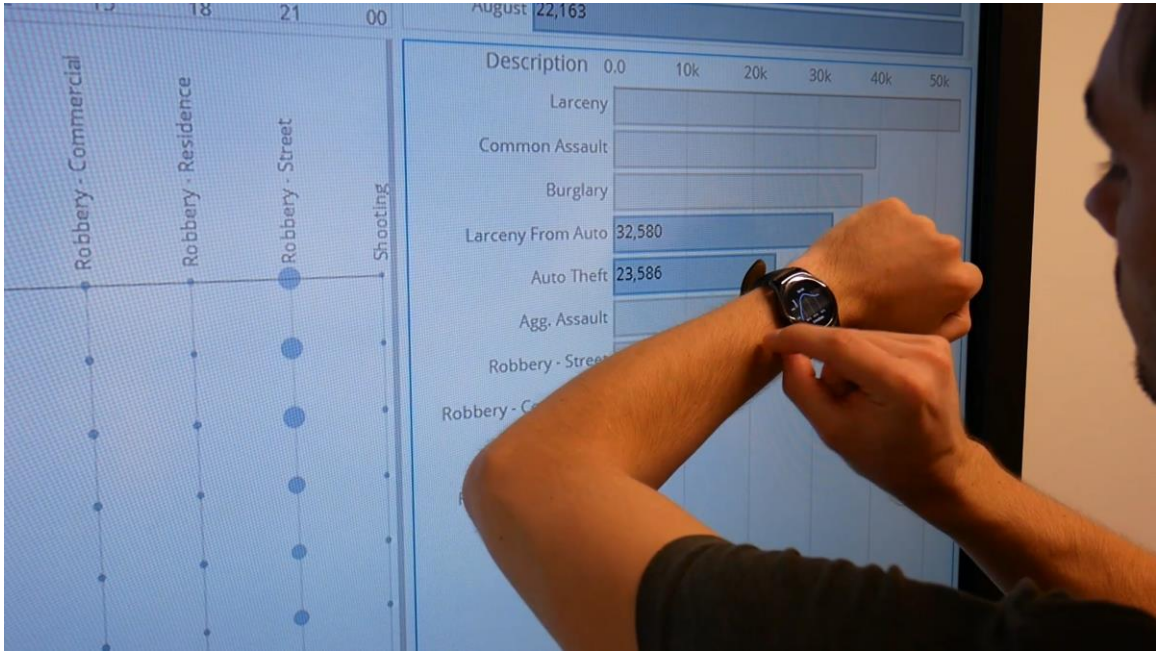
Push

Sets can be transferred between the devices via **pull** and **push** interaction on the watch

Swipe upwards the arm to **pull** the selection on the watch as a set

Swipe towards the hand to **push** the selection on the large display

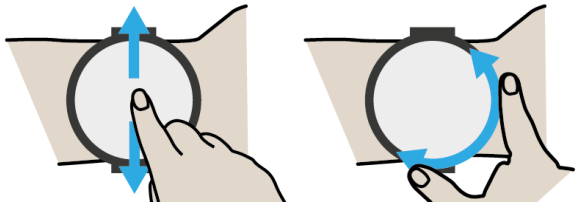


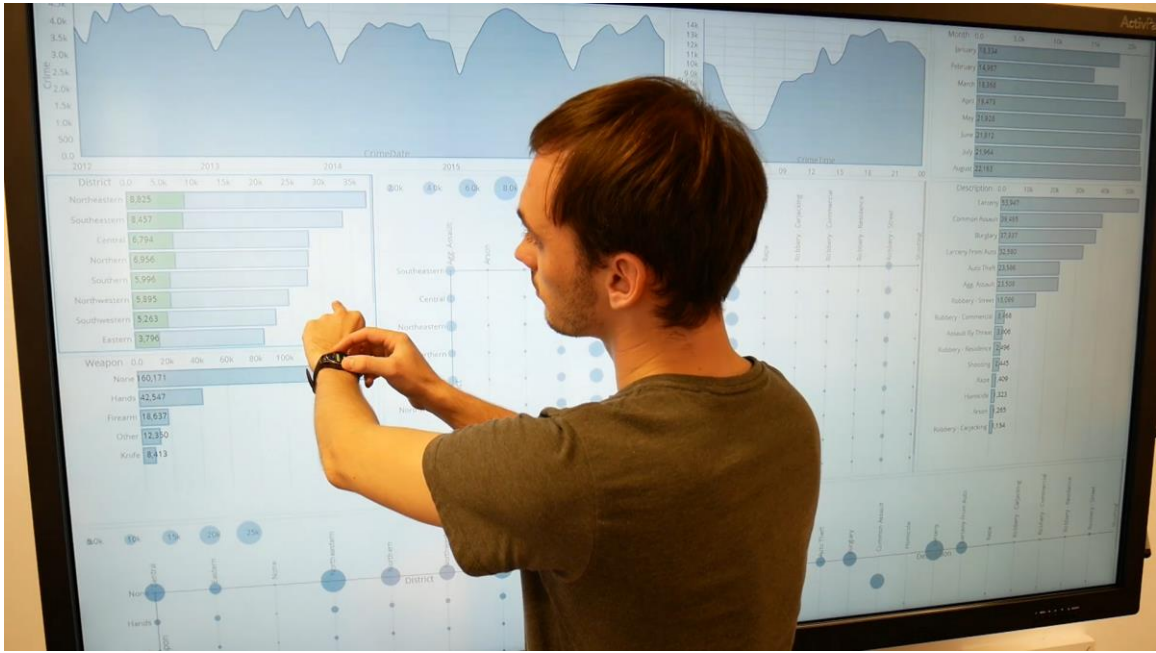


The stored sets on the smartwatch can be **previewed** in any other visualization

Focus another CA by holding or double-tapping

Swipe up and down or rotate the bezel to switch the previewed sets





Sets can also be **manipulated** and combined directly on the smartwatch

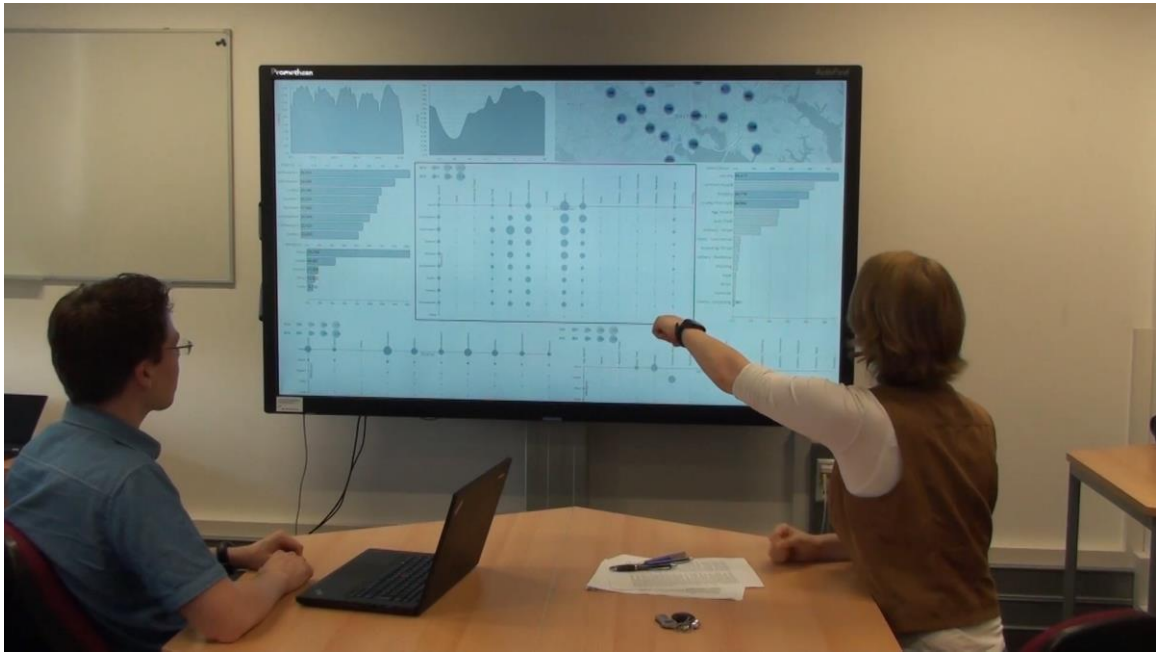
Select set(s) on the watch

Apply filters or bundle as well as combine multiple sets

All interaction techniques also allow for **remote interaction**

Focus CA through pointing with the watch

Pull, preview, and push as before



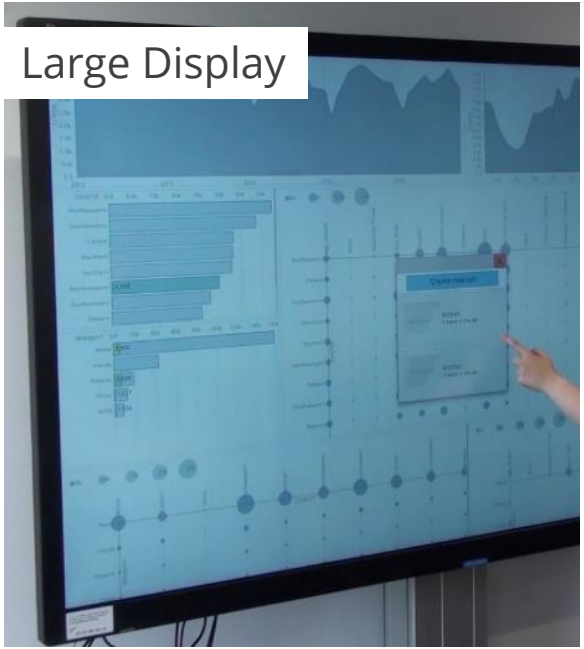
We conducted a user study to identify interaction **workflows** and differences in **insights**

10 Participants
5 female, 5 male

2 Interface conditions

Baltimore crime dataset

9 Tasks per condition
- finding values
- identifying extrema
- comparison



We observed more **flexible interaction workflows** when using the smartwatch

Moving back and forth
- 8 participants
- for visual comparison
- helps to gain overview of LD

Performing interaction remotely
- 3 participants
- for visual comparison, finding values, finding extrema
- avoid physical movements

Using the smartwatch also had an impact on the insights

More detailed observations for visual comparison

- focus on visualizations, not configuration

Focused interactions for more observations

- repeating interactions on LD

Open Research Questions & Outlook

What are differences when using another mobile device than a smartwatch?

What functions are further required to support collaboration?

How can we provide a general cross-device visual exploration framework?

In the big picture, smartwatches are a promising addition for multi-display environments

Flexible workflows are important to efficiently support users

Smartwatches can be a powerful toolbox complementing other devices

Importantly, they can be applied to applications beyond visual exploration

Thank you!

When David meets Goliath:
Combining Smartwatches with a Large Vertical Display for Visual Data Exploration

Tom Horak* - Interactive Media Lab, Technische Universität Dresden – horakt@acm.org
Sriram Karthik Badam* - University of Maryland, College Park, MD – sbadam@umd.edu
Niklas Elmqvist – University of Maryland, College Park, MD – elm@umd.edu
Raimund Dachselt – Interactive Media Lab, Technische Universität Dresden – dachselt@acm.org

*** The first two authors contributed equally**

imld.de/david-meets-goliath

ACM CHI 2018 • Montréal, QC, Canada

TECHNISCHE UNIVERSITÄT DRESDEN

INTERACTIVE MEDIA LAB DRESDEN

UNIVERSITY OF MARYLAND

HCIL