DEVELOPER DAYS 2014 EUROPE

Experiences Building The Largest Multitouch Screen in Latin America

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EDIS Interactive

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edisinteractive

Building The Largest Multitouch Screen in Latin America

Agenda

A talk is to share my experience building a huge multitouch screen!

... and how Qt helped along the adventure

- Why this monster multitouch screen?
  - What we started doing & what we ended doing
  - Where & how was it done
- What's inside?
  - Qt at the tracker & sensor multiplexor
  - Qt Quick at the UI level

Qt truly everywhere and we really pushed some limits.

Building The Largest Multitouch Screen in Latin America

Ariel Molina (PhD Cand)

- Founder & lead developer at EDIS Interactive
- Incessant bug reporter (desert) at QtC Bugtracker
- Qt Ambassador, Evangelist at academia & industry at México

EDIS Interactive

- Creates huge interactive surfaces, either touch or other
- Academy, education & fun, and recently alongside medical partners
- We love what we do

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Building The Largest Multitouch Screen in Latin America

This is what we started doing:

QGLWidget for Qt 4.x and lot's of custom animation

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This is what we ended doing:

Qt 5 C++, OpenCV, Qt Quick, QPA Plugins, Custom Affectors, C++ Quick

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Where was it done?

- IBERO University at Puebla, México

  (That's 90km southwest of Mexico City)

CONACYT Supported Federal Proyect

- Mexican Council for Science and Technology
- EDIS Interactive led two small teams at two universities,
  - IBERO and UPSLP
- Evolve LayerFX Interactive Bars for fun into a huge multi touchscreen
- Kickstart EDIS Interactive Startup

CONACYT
Consejo Nacional de Ciencia y Tecnología

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IBERO
PUEBLA ®

UNIVERSIDAD POLITÉCNICA DE SAN LUIS POTOSÍ

Building The Largest Multitouch Screen in Latin America

How was it done?

Hardware:

- **Two** 4 meter tempered glass units (currently the only in México)
- Laser light plane and **four** infrared-filtered cameras
- **Three** projectors (Will upgrade to four)
- Accelerated Xinerama over two nVidia GTX 650, an Intel Core i3

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How was it done?

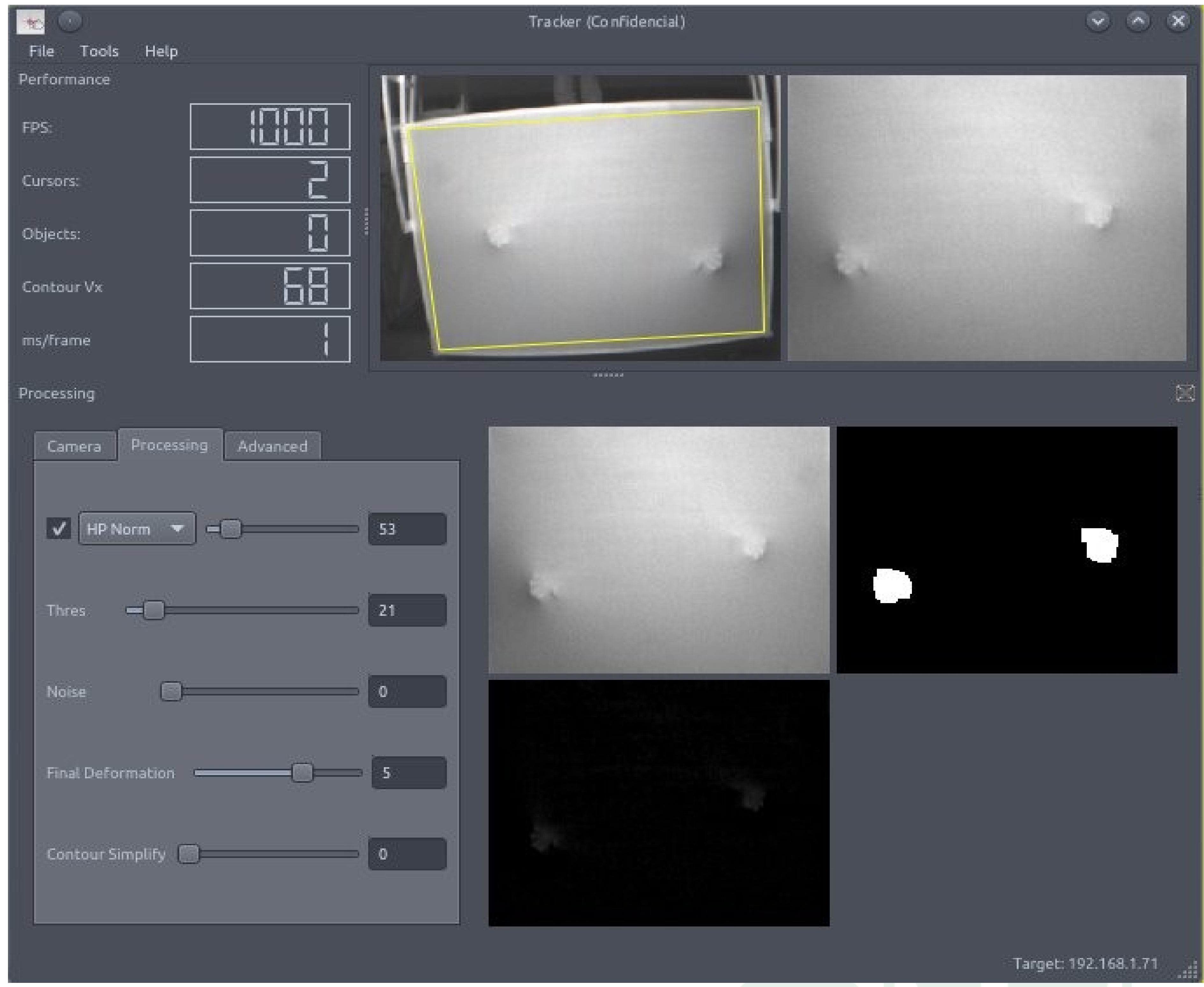
Software

- Qt 4.8, then upgraded to Qt 5
- There are several pieces of Qt software
  - High-speed finger tracker using OpenCV *(no reliable CCV by then)*
  - Console multitracker-muxer, “unlimited” mosaiced cameras
    (CCV still severely lags behind at this moment)
  - And a homemade **qmlscene**-like viewer

Software (1/3). The tracker.

- Originally written in C++ Qt Widgets for ~Qt 4.6, with OpenCV lib
- Eventually ported to Qt 5
- Interesting bits:
  - IplImage ↔ QImage translators
  - Split Core & UI
  - Core runs in own thread (shared mem with UI)
  - Originally wrapped official TUIO_CPP

    (100% rewritten with QtNetwork, faster, cleaner)
  - Tangible & Silhouette data via OSC extensions
- We've got it to run really fast, > 200 FPS



FPS: 1000
Cursors: 2
Objects: 0
Contour Vx: 68
ms/frame: 1

✓ HP Norm: 53
Thres: 21
Noise: 0
Final Deformation: 5
Contour Simplify: 0

Target: 192.168.1.71

Software (1/3). The tracker interesting bits

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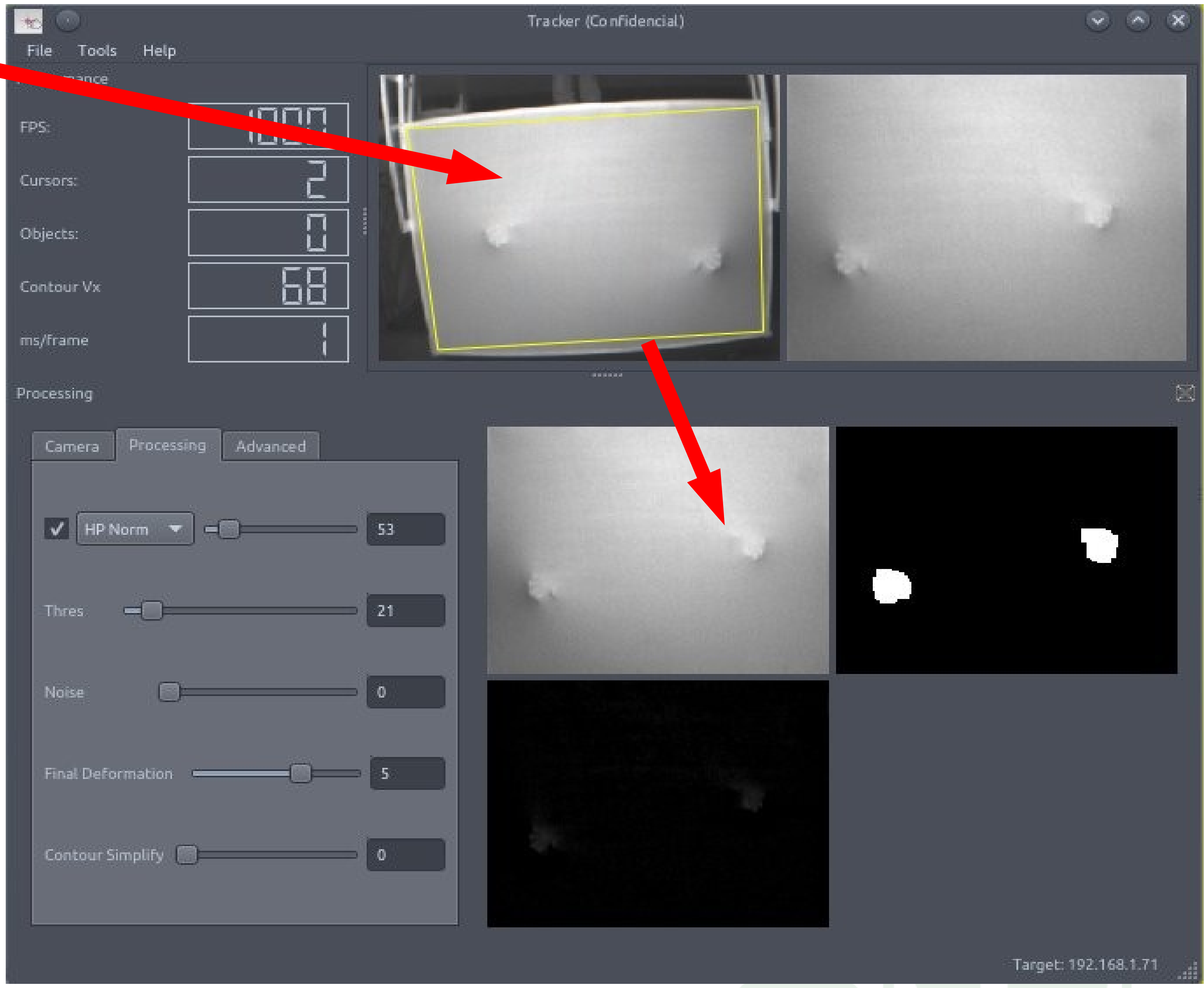

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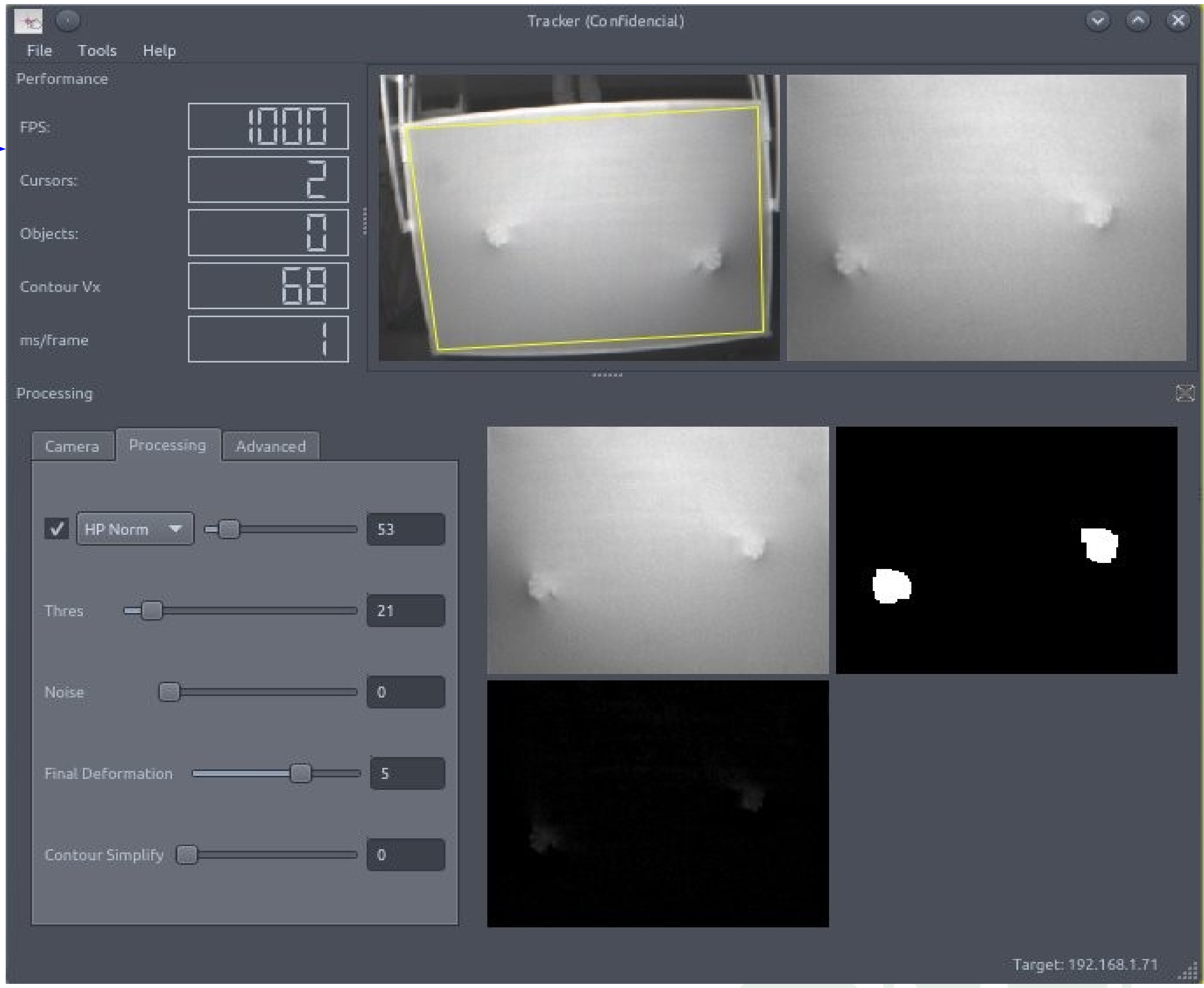

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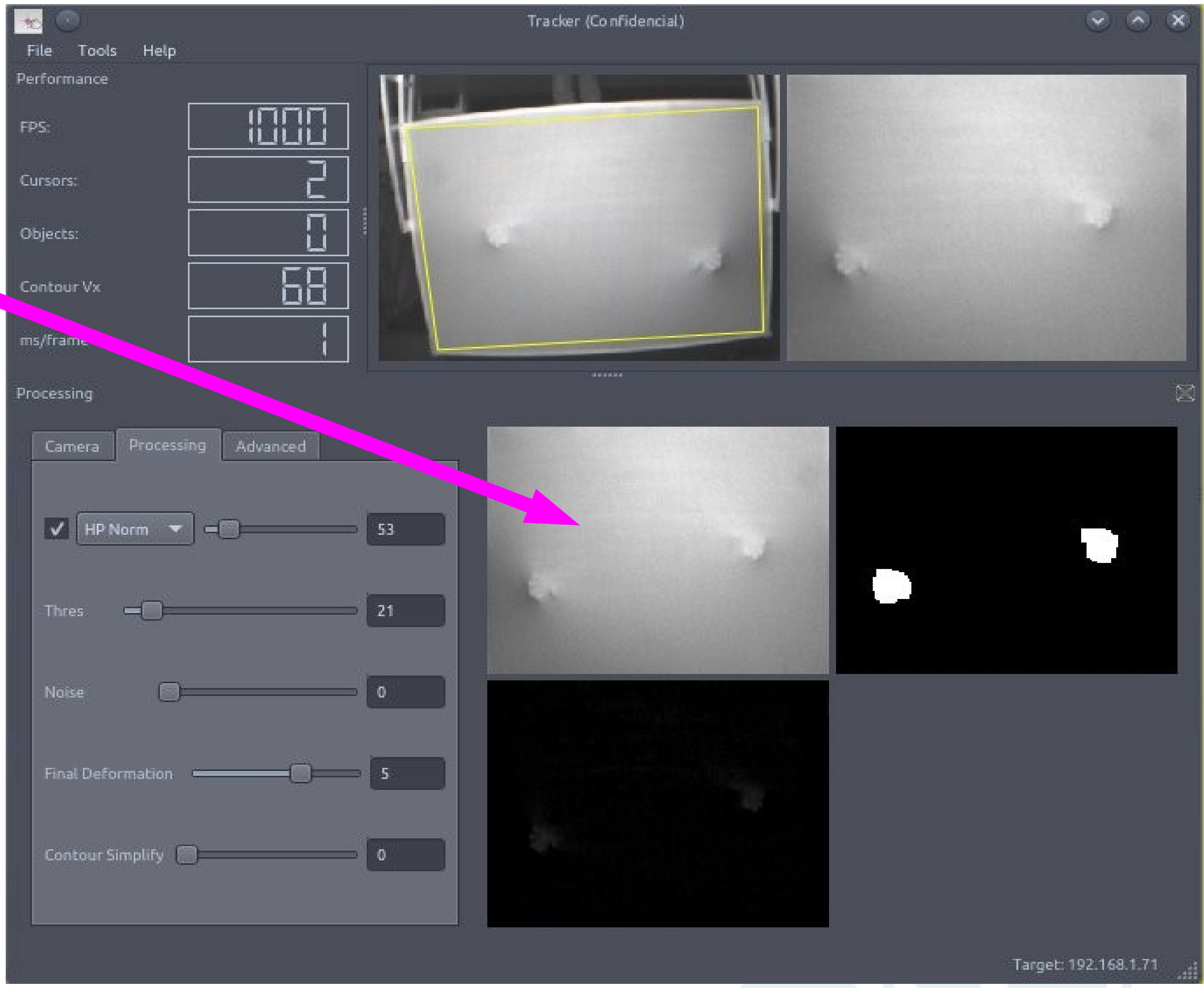

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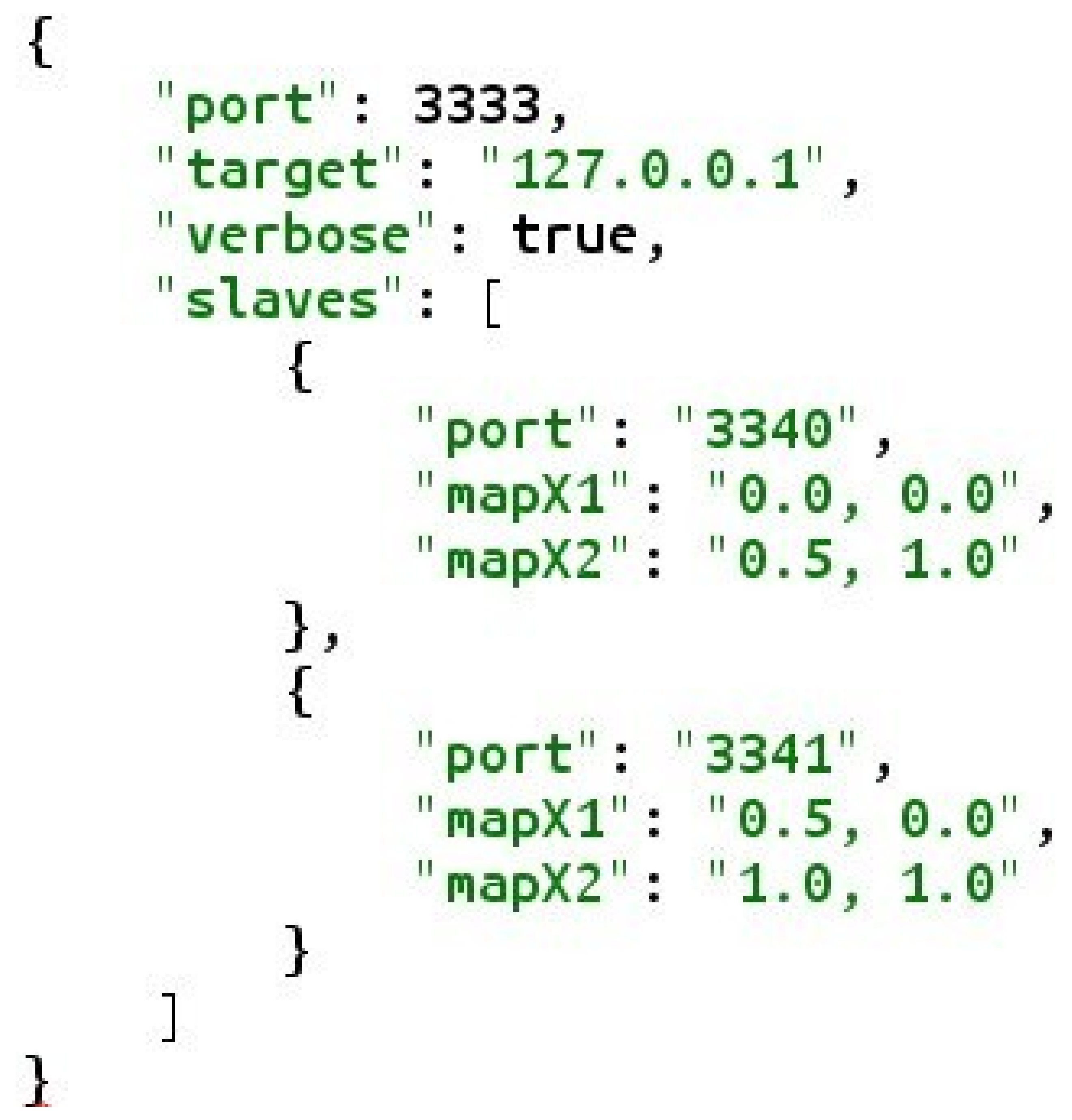
Building The Largest Multitouch Screen in Latin America

Software (2/3).

The “tarengo” general-mosaic tracker multiplexor.

- Takes any amount of TUIO inputs → Delivers a single output
- Qt Console App with own QtNetwork OSC parser
- Simple JSon configuration
- Launches slave listeners and mixes into a single TUIO output
- EXTREMELY fast
  - Tested with up to 10 trackers @ 120 FPS **each**
  - Delivers normal 120FPS flow
  - CONS: Still lacks a couple of useful things



```
{
    "port": 3333,
    "target": "127.0.0.1",
    "verbose": true,
    "slaves": [
        {
            "port": "3340",
            "mapX1": "0.0, 0.0",
            "mapX2": "0.5, 1.0"
        },
        {
            "port": "3341",
            "mapX1": "0.5, 0.0",
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        }
    ]
}
```
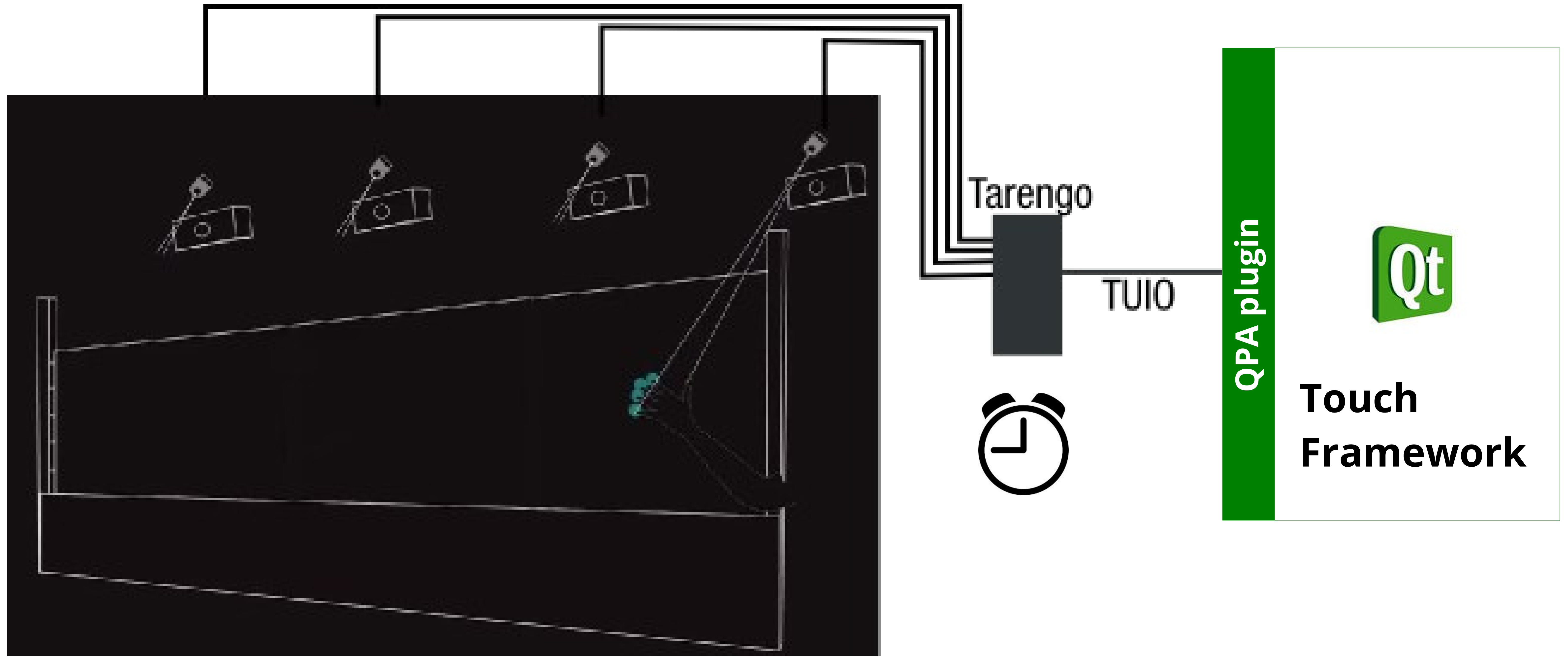

Building The Largest Multitouch Screen in Latin America

Software (2/3).

The “tarengo” general-mosaic tracker multiplexor.

- Takes any amount of TUIO inputs → Delivers a single output
- Any possible mosaic: N x M



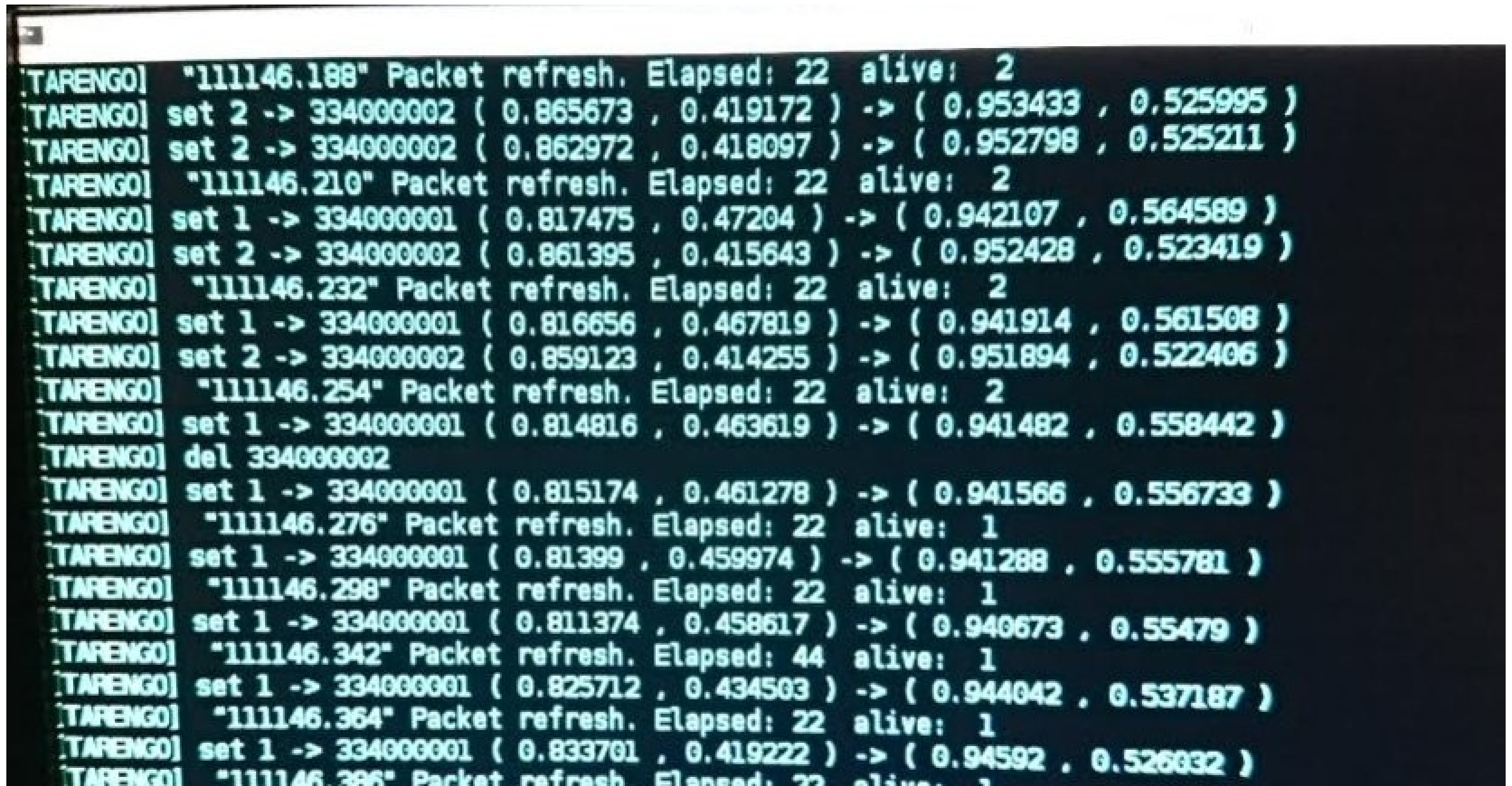
With a QPA plugin it is now a normal multitouch screen, so everything works as expected, including QtQuick.

Building The Largest Multitouch Screen in Latin America

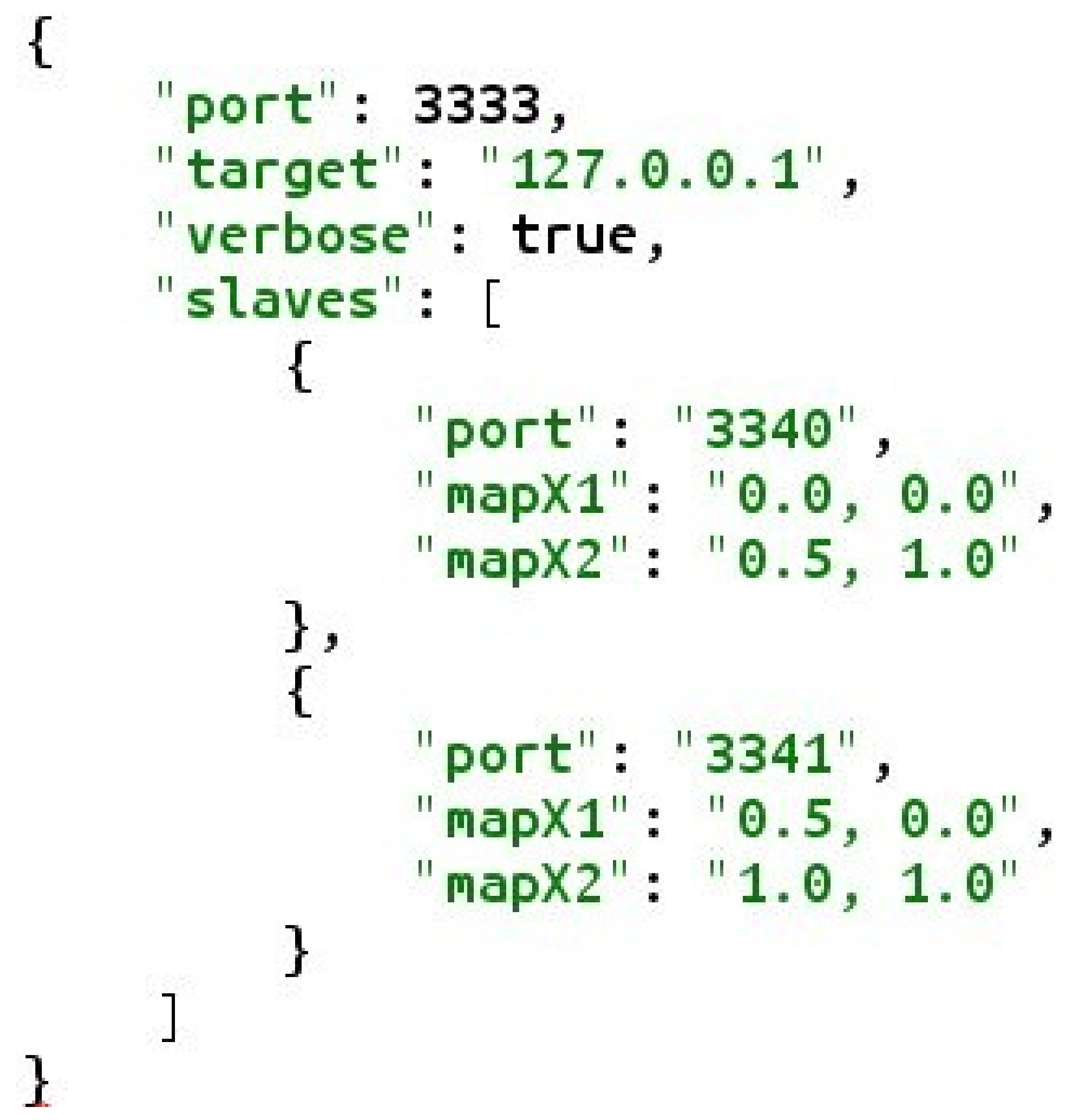
Software (2/3).

The “tarengo” general-mosaic tracker multiplexor.

- Qt Console App with own QtNetwork-based OSC parser
- Simple JSon configuration
- Launches slave listeners and mixes into a single TUIO output



```
[TARENGO]  "111146.188" Packet refresh. Elapsed: 22  alive:  2
[TARENGO] set 2 -> 334000002 ( 0.865673 , 0.419172 ) -> ( 0.953433 , 0.525995 )
[TARENGO] set 2 -> 334000002 ( 0.862972 , 0.418097 ) -> ( 0.952798 , 0.525211 )
[TARENGO]  "111146.210" Packet refresh. Elapsed: 22  alive:  2
[TARENGO] set 1 -> 334000001 ( 0.817475 , 0.47204 ) -> ( 0.942107 , 0.564589 )
[TARENGO] set 2 -> 334000002 ( 0.861395 , 0.415643 ) -> ( 0.952428 , 0.523419 )
[TARENGO]  "111146.232" Packet refresh. Elapsed: 22  alive:  2
[TARENGO] set 1 -> 334000001 ( 0.816656 , 0.467819 ) -> ( 0.941914 , 0.561508 )
[TARENGO] set 2 -> 334000002 ( 0.859123 , 0.414255 ) -> ( 0.951894 , 0.522406 )
[TARENGO]  "111146.254" Packet refresh. Elapsed: 22  alive:  2
[TARENGO] set 1 -> 334000001 ( 0.814816 , 0.463619 ) -> ( 0.941482 , 0.558442 )
[TARENGO] del 334000002
[TARENGO] set 1 -> 334000001 ( 0.815174 , 0.461278 ) -> ( 0.941566 , 0.556733 )
[TARENGO]  "111146.276" Packet refresh. Elapsed: 22  alive:  1
[TARENGO] set 1 -> 334000001 ( 0.81399 , 0.459974 ) -> ( 0.941288 , 0.555781 )
[TARENGO]  "111146.298" Packet refresh. Elapsed: 22  alive:  1
[TARENGO] set 1 -> 334000001 ( 0.811374 , 0.458617 ) -> ( 0.940673 , 0.55479 )
[TARENGO]  "111146.342" Packet refresh. Elapsed: 44  alive:  1
[TARENGO] set 1 -> 334000001 ( 0.825712 , 0.434503 ) -> ( 0.944042 , 0.537187 )
[TARENGO]  "111146.364" Packet refresh. Elapsed: 22  alive:  1
[TARENGO] set 1 -> 334000001 ( 0.833701 , 0.419222 ) -> ( 0.94592 , 0.526032 )
[TARENGO]  "111146.386" Packet refresh. Elapsed: 22  alive:
```



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}
```

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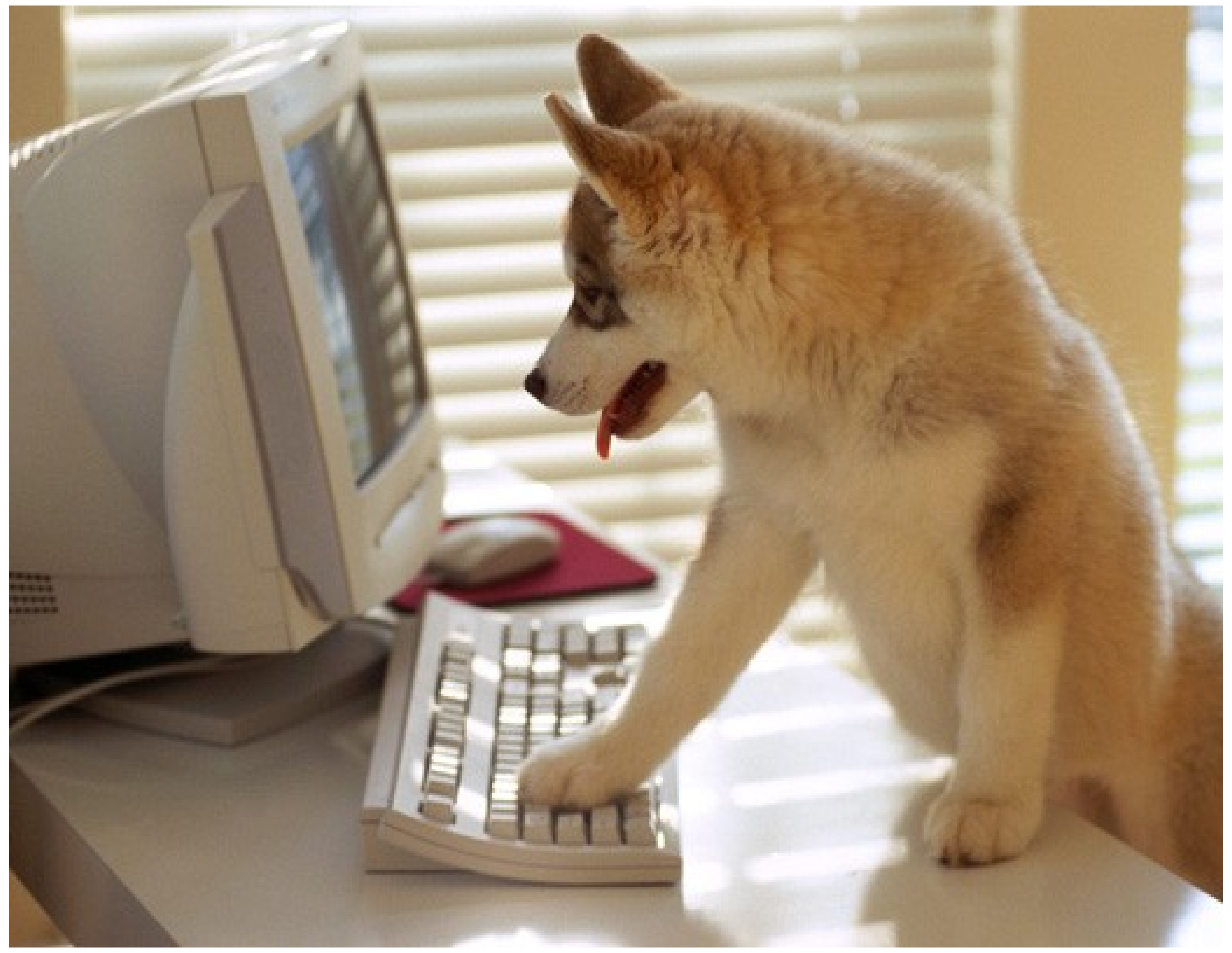
Software (3/3). The User Interface.

- **Target user A: College student**
  - **Designers, close to zero technical know-how**
  - Some of them, just college rookies
  - Strong QtQuick preference
  - **Works at first shot or hate it!**
- Target user B: Senior Developer
  - Wizard-level technical knowledge
  - No problems with these
- How to deploy apps, easy... no really easy
  - First idea: **QtCreator Deployment**...

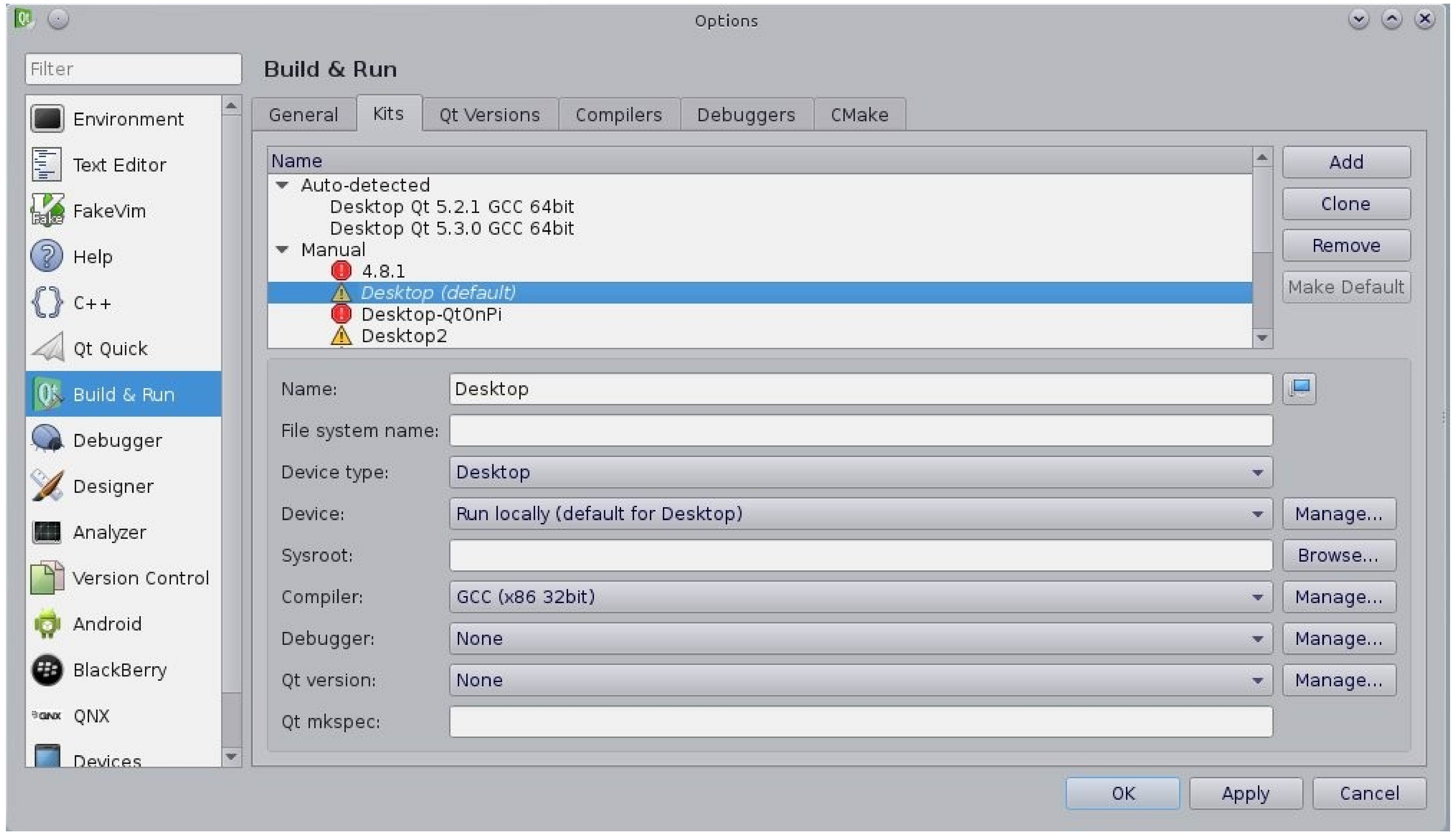

I can haz multitouch app!

... magically uploading: OK

Image: Courtesy of emanueleferonato.com

Software (3/3). The User Interface.

- **Target user A: College student**
- How to deploy apps, easy... no really easy: 1) **QtCreator Deployment**...



Name
- Auto-detected
  - Desktop Qt 5.2.1 GCC 64bit
  - Desktop Qt 5.3.0 GCC 64bit
- Manual
  - 4.8.1
  - Desktop (default)
  - Desktop-QtOnPi
  - Desktop2

Name:	Desktop
File system name:	
Device type:	Desktop
Device:	Run locally (default for Desktop)
Sysroot:	
Compiler:	GCC (x86 32bit)
Debugger:	None
Qt version:	None
Qt mkspec:	

1) Select compiler
2) Create Linux Generic Device, Set IP address, password, test
3) Create New Kit, Duplicate Settings
4) Select Generic Device, Select your device
5) Select New Kit
6) Oh, and don't forget to be in the LAN

Building The Largest Multitouch Screen in Latin America

Software (3/3). The User Interface.

- **Target user A: College student**
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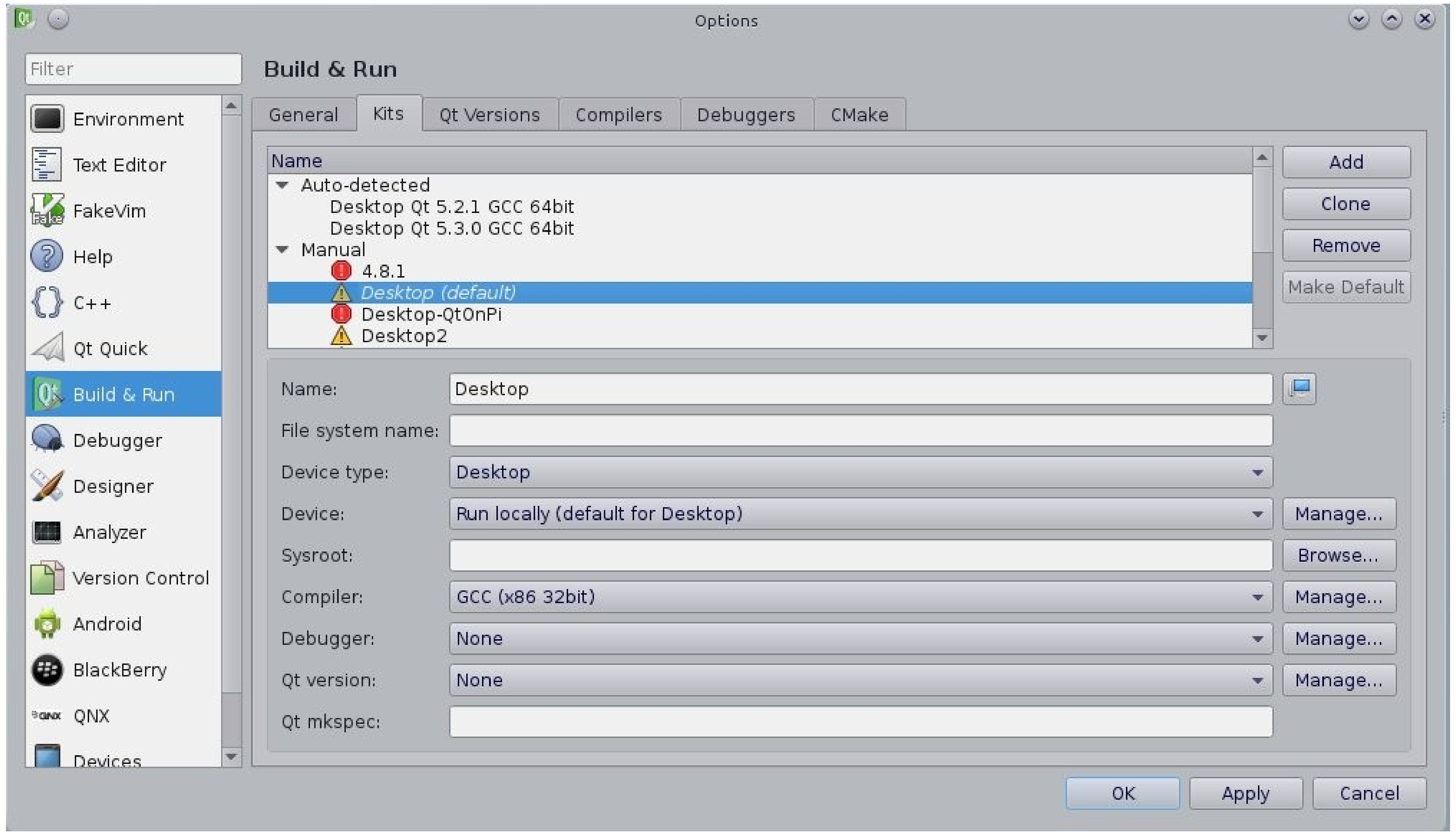

Options

Build & Run

Tabs: General | Kits | Qt Versions | Compilers | Debuggers | CMake

Sidebar: Environment, Text Editor, FakeVim, Help, C++, Qt Quick, Build & Run, Debugger, Designer, Analyzer, Version Control, Android, BlackBerry, QNX, Devices

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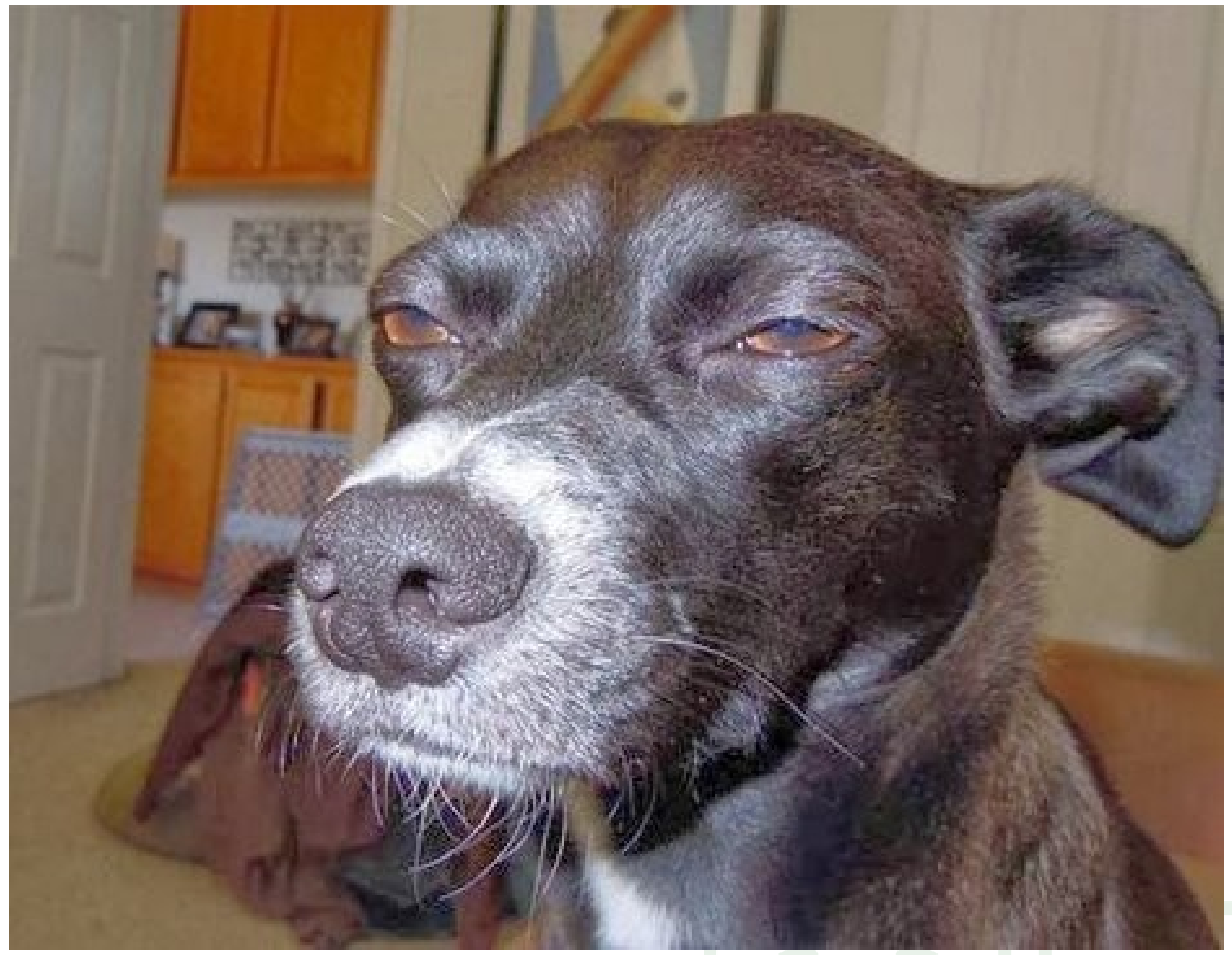

You promised it to be easy

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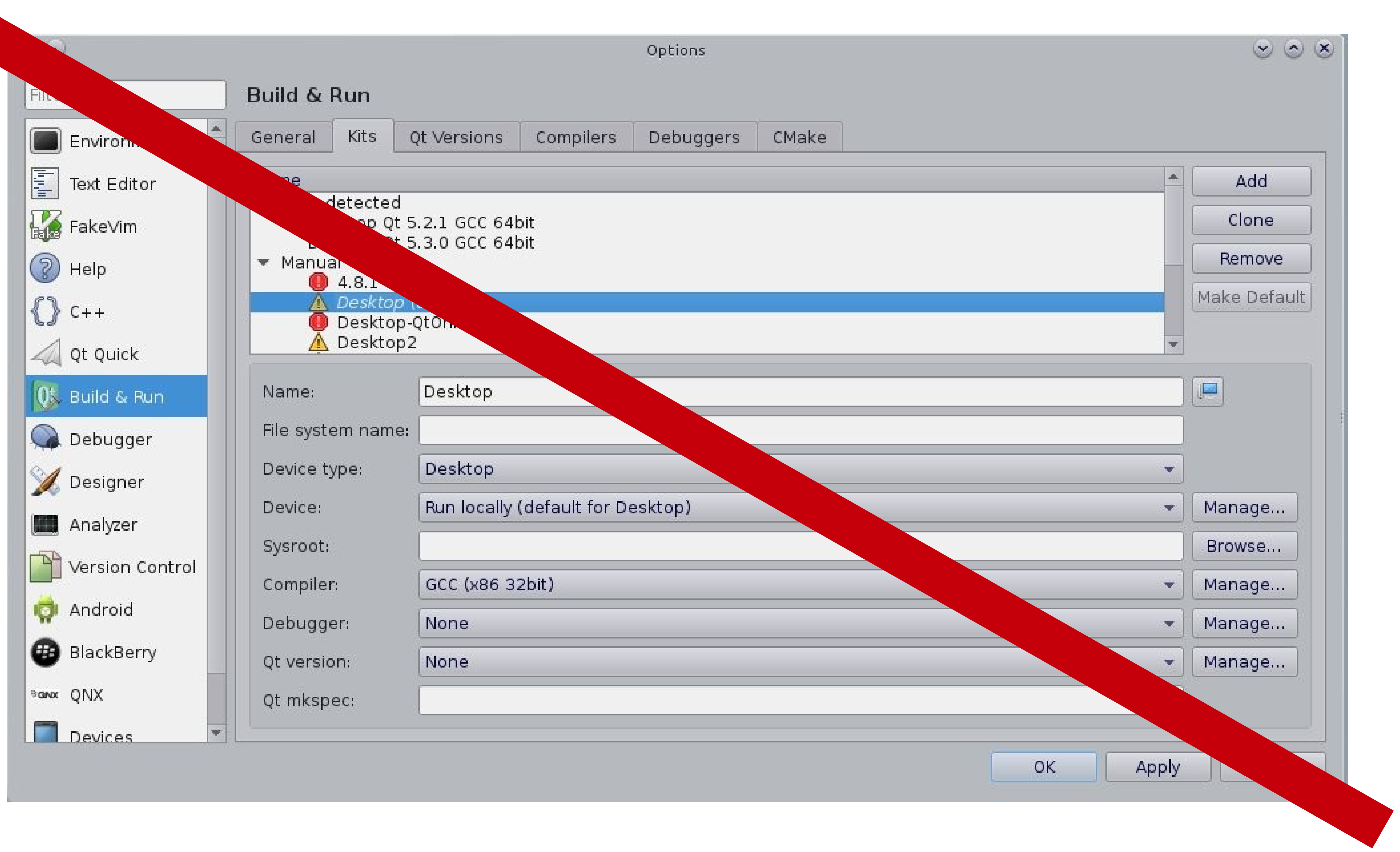

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Manual
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Desktop (
Desktop-QtOn…
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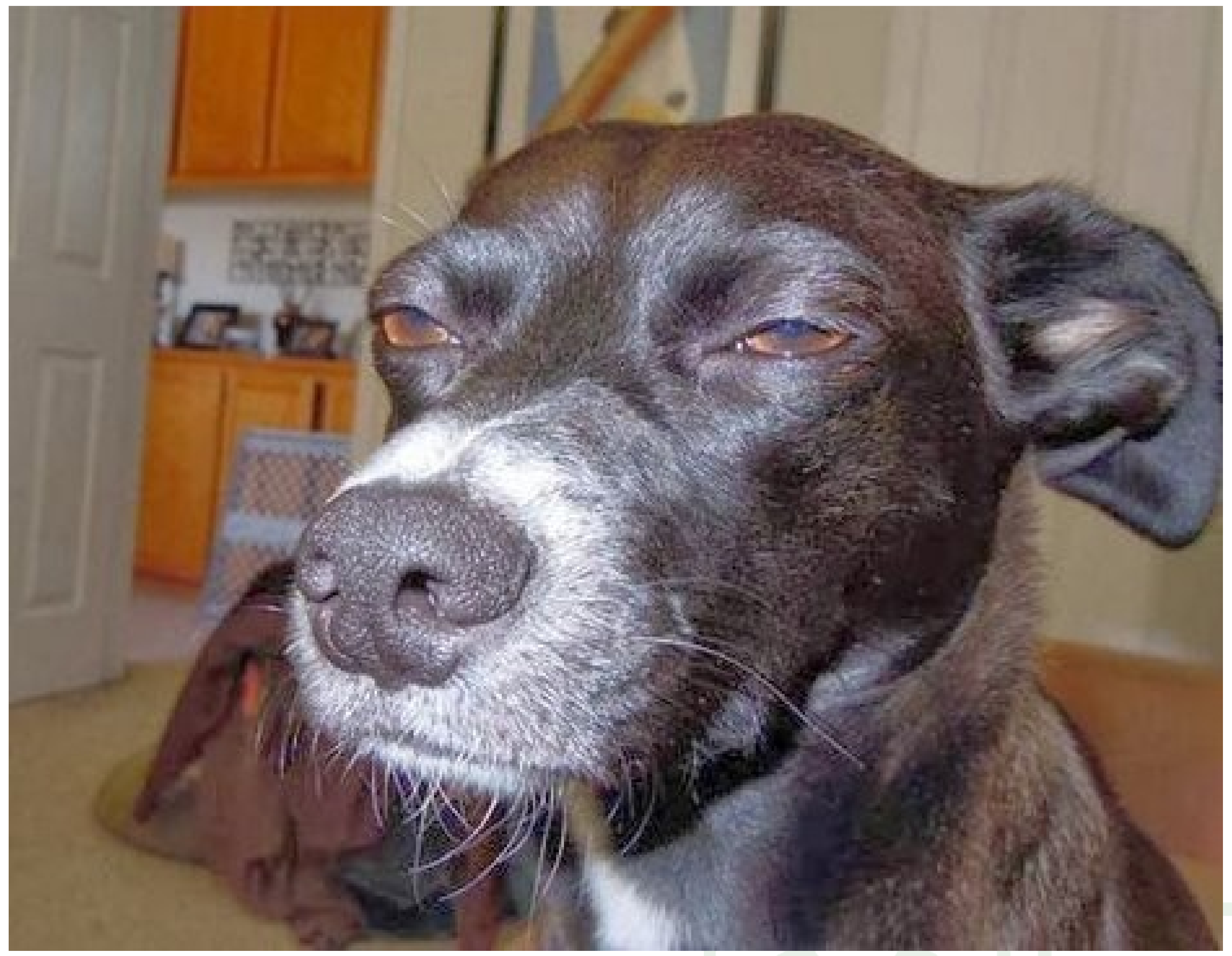
Add | Clone | Remove | Make Default

Name: Desktop
File system name:
Device type: Desktop
Device: Run locally (default for Desktop) — Manage...
Sysroot: — Browse...
Compiler: GCC (x86 32bit) — Manage...
Debugger: None — Manage...
Qt version: None — Manage...
Qt mkspec:

OK | Apply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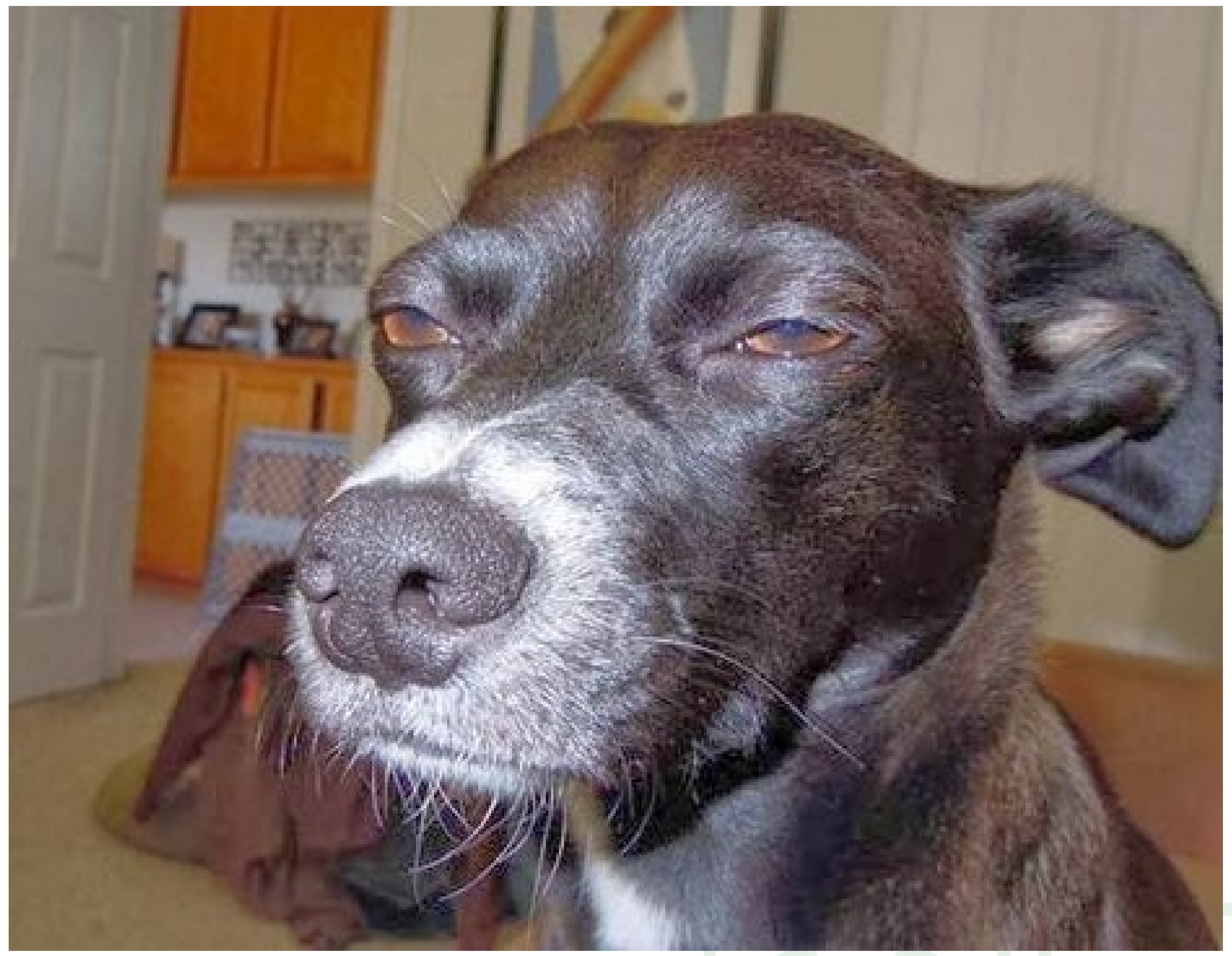
Software (3/3). The User Interface.

- **Target user A: College student**
- How to deploy apps, easy.
- **Idea #2**
  - We setup Samba shared folder
  - Create Qt Quick UI (they already have some)
  - Move Folder
  - We make UI load it magically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Building The Largest Multitouch Screen in Latin America

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- **Idea #2: Samba shared folder**
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  - Move Folder
  - We make UI load it magically, so...
- ... we created a **qmlscene** inspired viewer

  ... monitoring a local folder,

  ... and it worked like a charm

I can haz multitouch app!

... magically samba uploading: OK

Building The Largest Multitouch Screen in Latin America

Software (3/3). The User Interface.

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PROBLEM SOLVED

I can haz multitouch app!

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Software (3/3). The User Interface.

- Target user A: College student deploying apps
- **Idea #2: Samba shared folder**
  - ...
- We created a **qmlscene** inspired viewer
  - And it worked like a charm
  - But it was **not charming**, need to make it "Cute"

I can haz multitouch app!

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Building The Largest Multitouch Screen in Latin America

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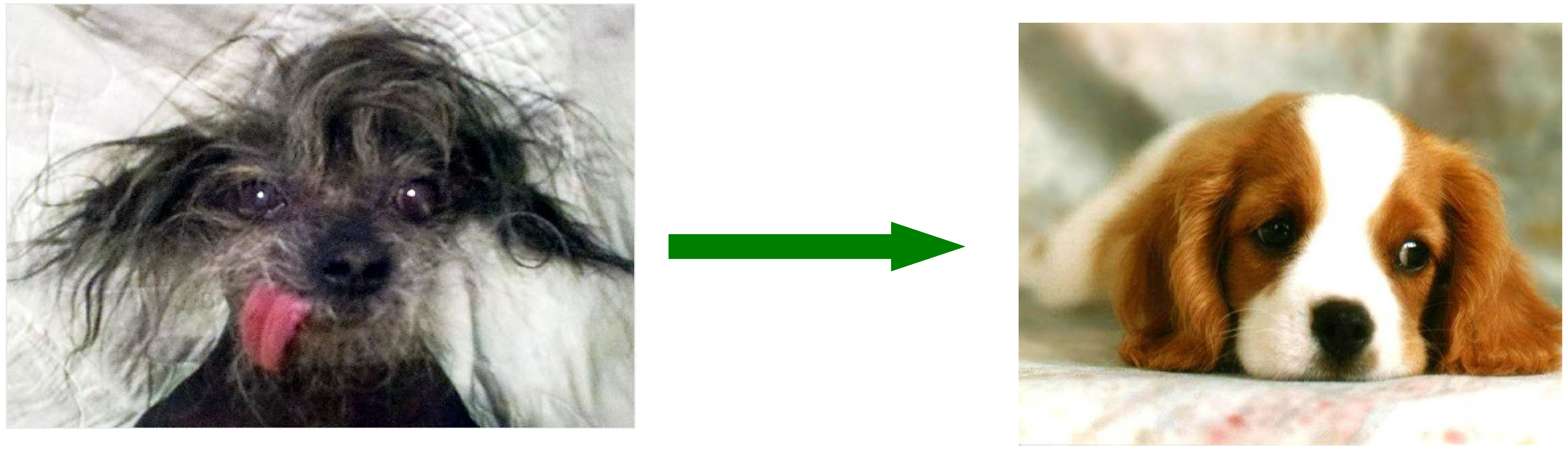

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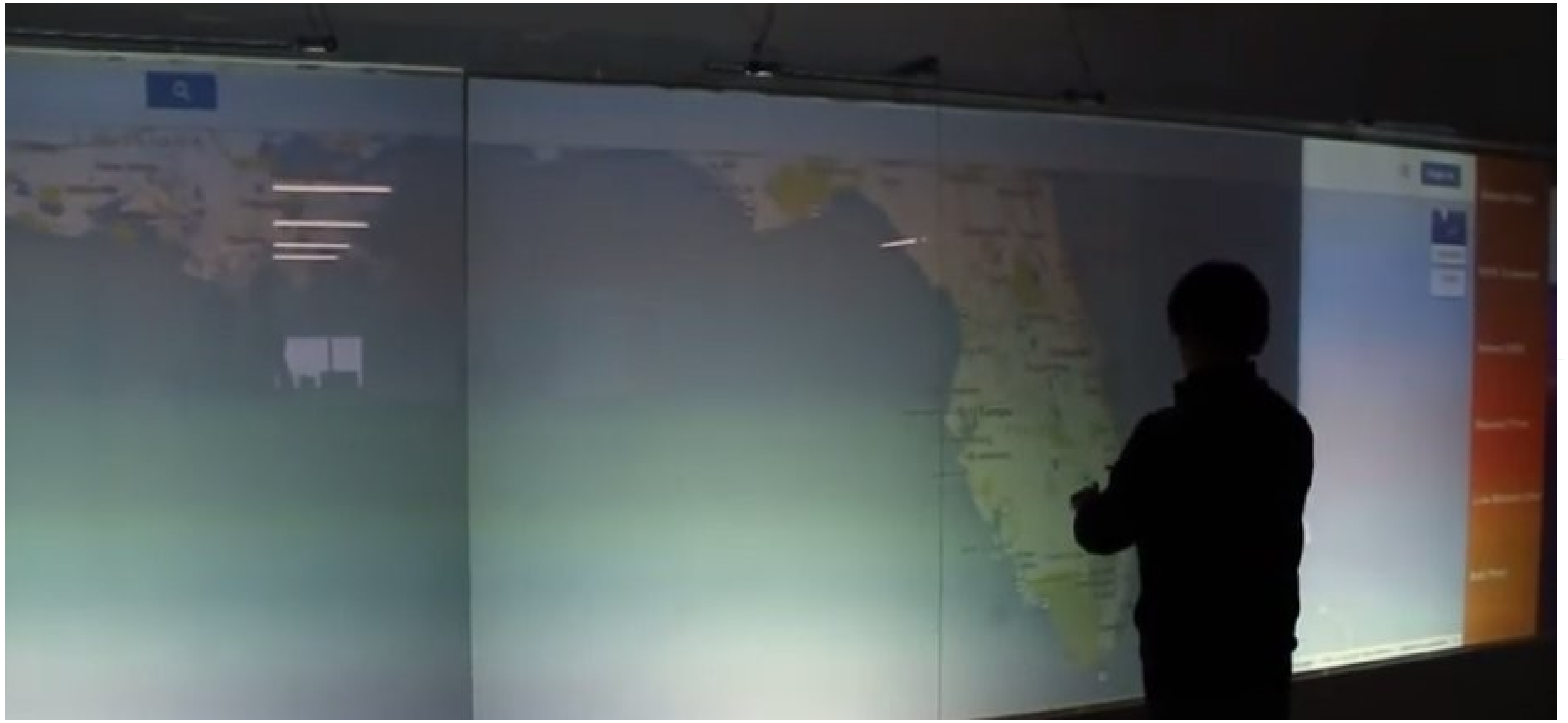
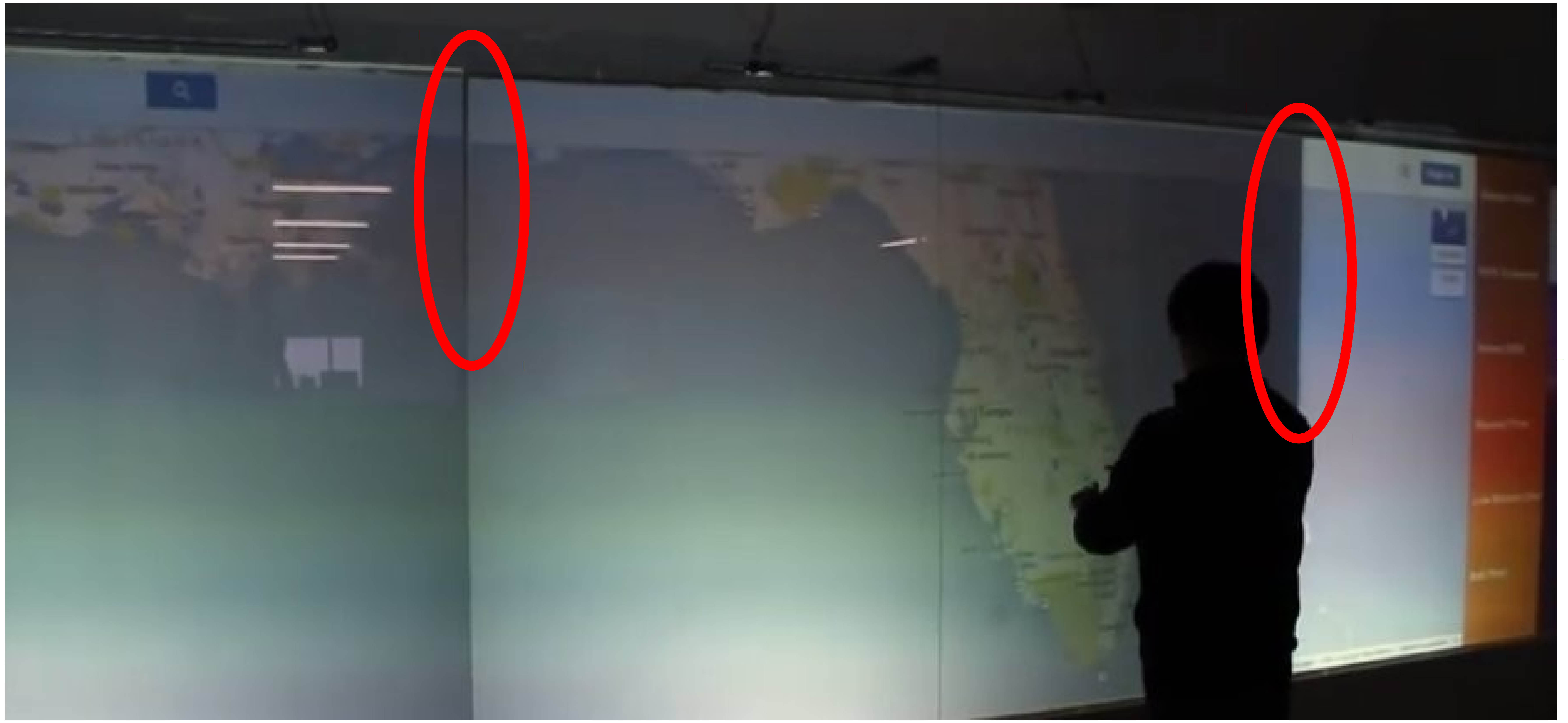
Software (3/3). The User Interface, making it "Cute".

- Uglyness due to projector non-blending
- More visible for expectators → unprofessional look



Software (3/3). The User Interface, making it “Cute”.

- **Uglyness** due to lack of projector blending
- More visible for expectators → unprofessional look



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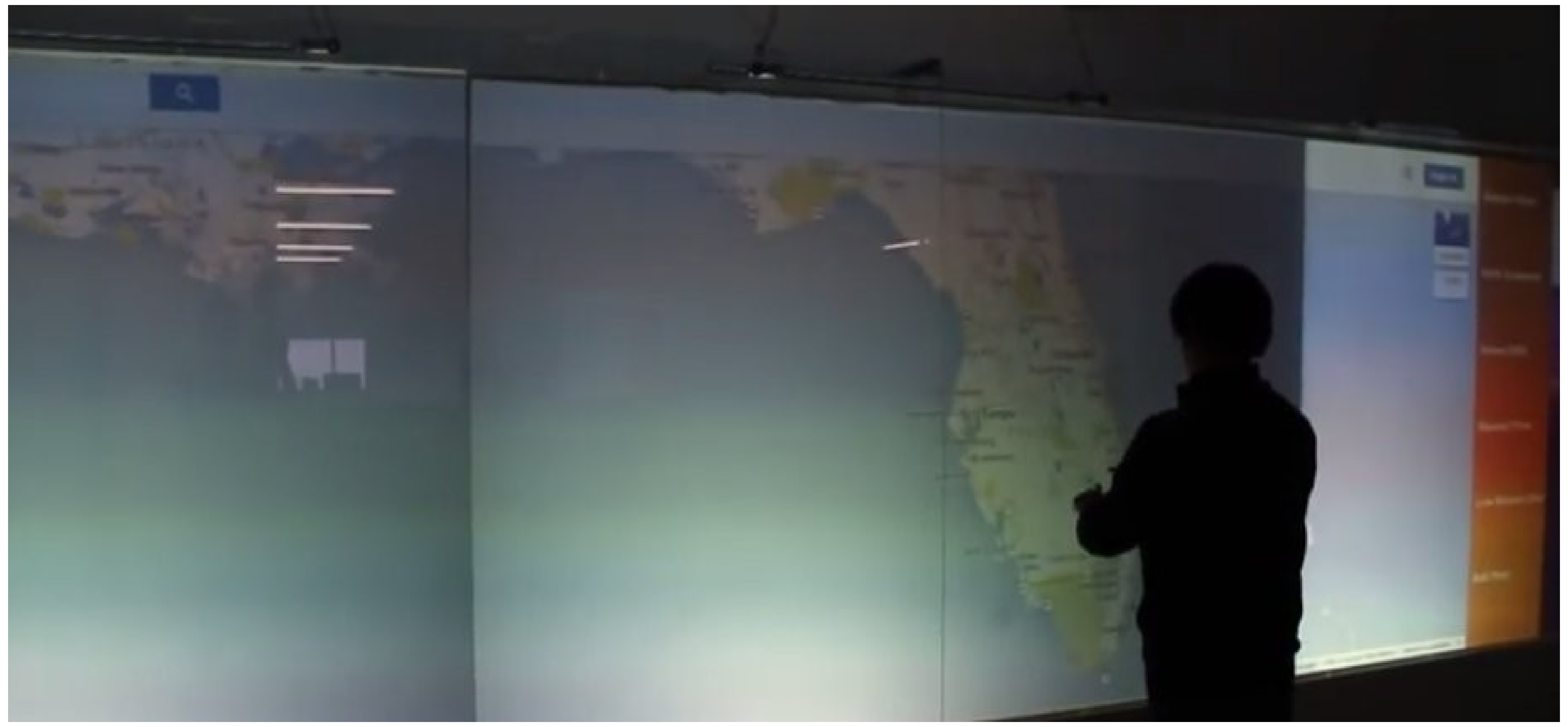
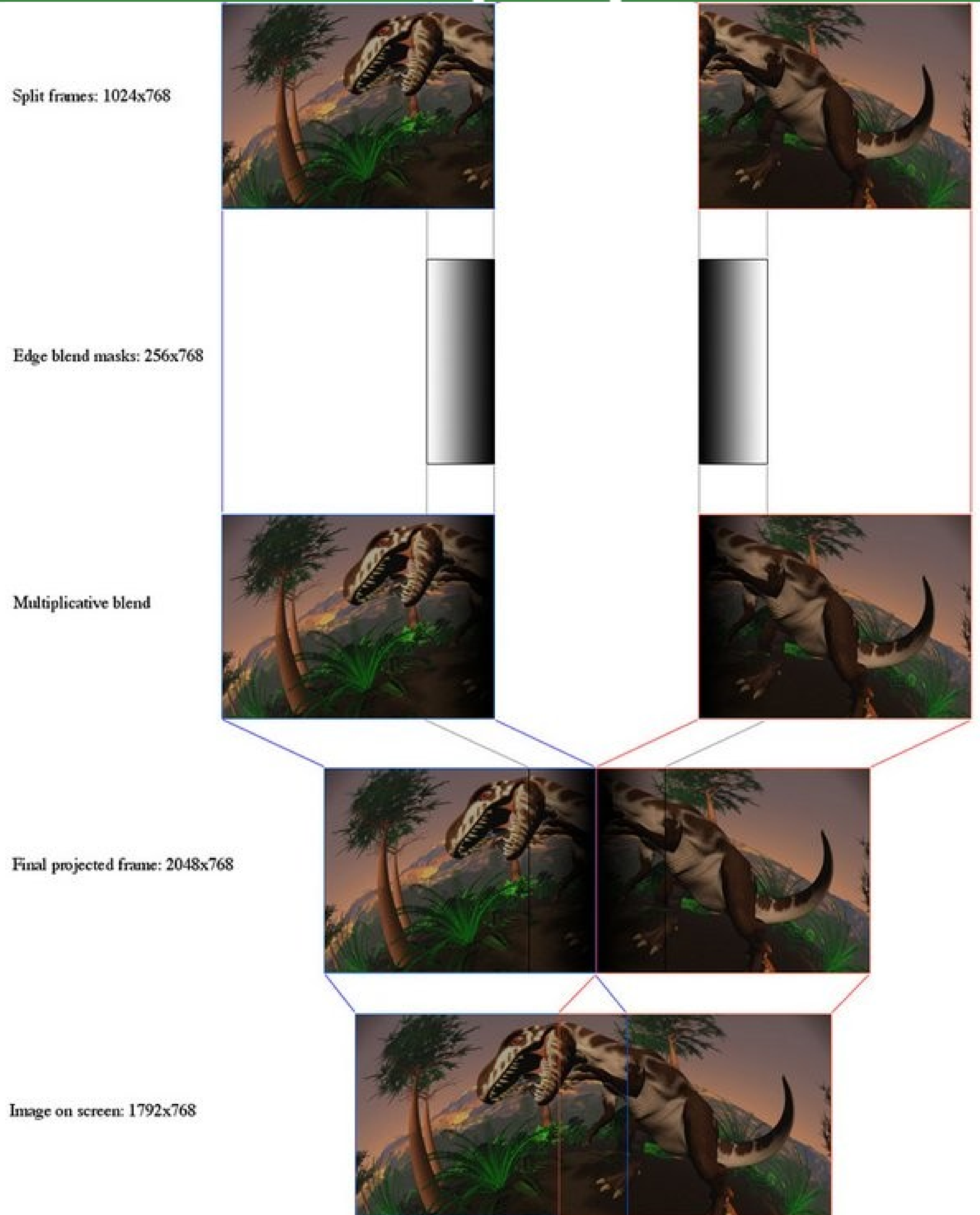
Software (3/3).

The User Interface, making it "Cute".

But this is a whole different problem




Split frames: 1024x768
Edge blend masks: 256x768
Multiplicative blend
Final projected frame: 2048x768
Image on screen: 1792x768

Edge blending using commodity projectors
by Paul Bourke
http://paulbourke.net/texture_colour/edgeblend/

Building The Largest Multitouch Screen in Latin America

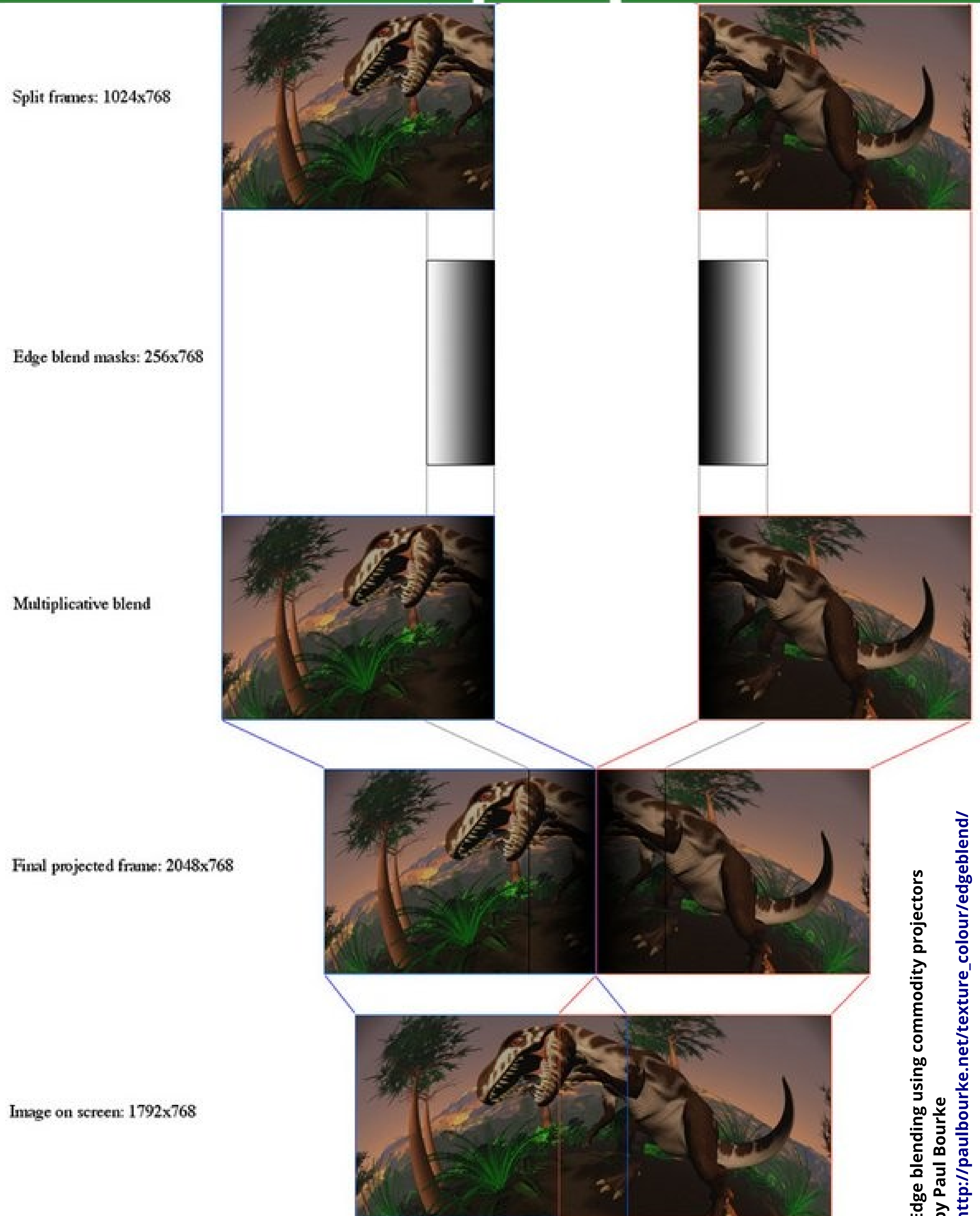
Software (3/3).

The User Interface, Edge Blending

Non trivial techniques, commercial software is expensive, see Watchout or Rhino

General Idea:

1) Overlap projector instead of align
2) Split projector segments
3) Darken edges to compensate brightness
4) Rewarp mouse/touch coordinates
5) ...
6) Fun



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dge blending using commodity projectors
y Paul Bourke
ttp://paulbourke.net/texture_colour/edgeblend/

Building The Largest Multitouch Screen in Latin America

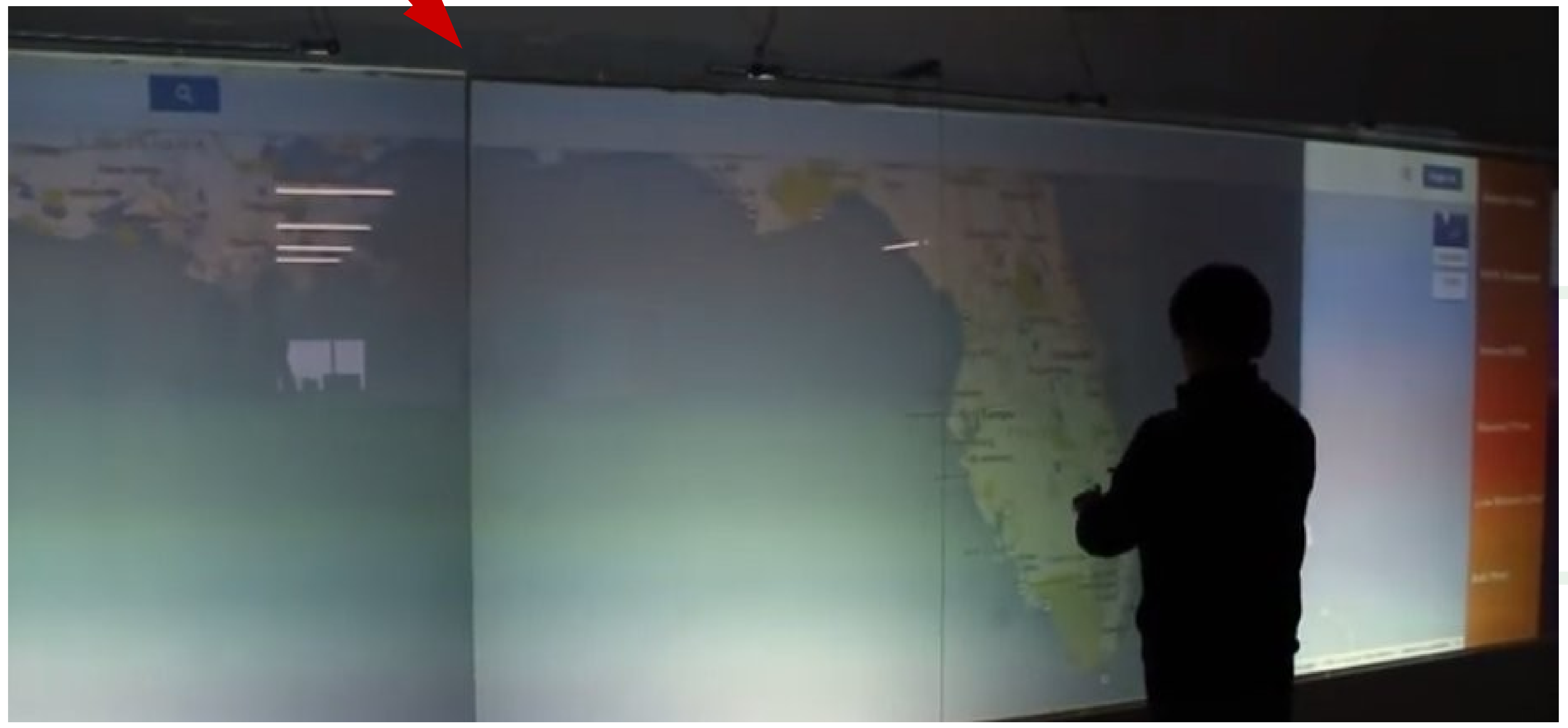
Software (3/3).

The User Interface, Edge Blending

General Idea:

1) Overlap projector instead of align
   1) Past: we aligned carefully projector
   2) Now: we overlap them **carelessly**

easy part!



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Building The Largest Multitouch Screen in Latin America

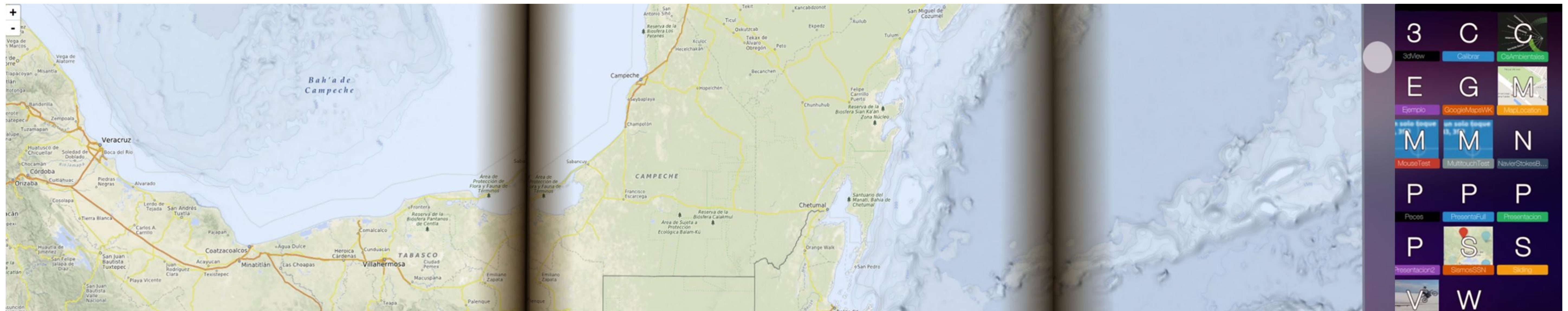
Software (3/3).

The User Interface, Edge Blending

General Idea Step 2 & 3:

2) Split projector segments
3) Darken edges to compensate brightness

QtQuick is a Texture
1) Put whole scene as ShaderSource
2) Render just the needed slice
3) While being there, darken edges



Building The Largest Multitouch Screen in Latin America

Software (3/3).

The User Interface, Edge Blending

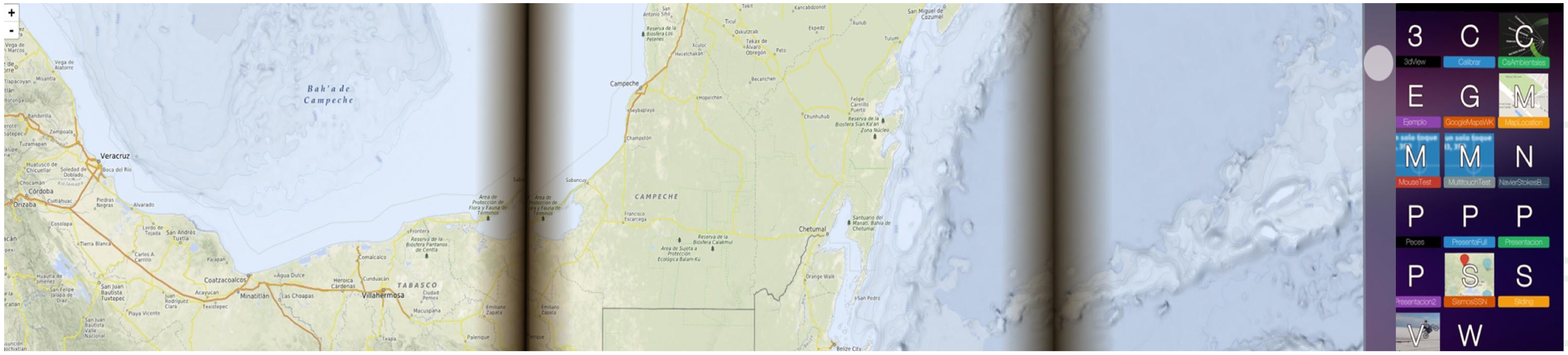
General Idea Step 2 & 3: Split & Darken

QtQuick Tree as a Texture

1) Put whole scene as ShaderEffectSource

2) Render just the needed slice using ShaderEffect (N-times)

3) While being there, darken edges



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Software (3/3).

The User Interface, Edge Blending

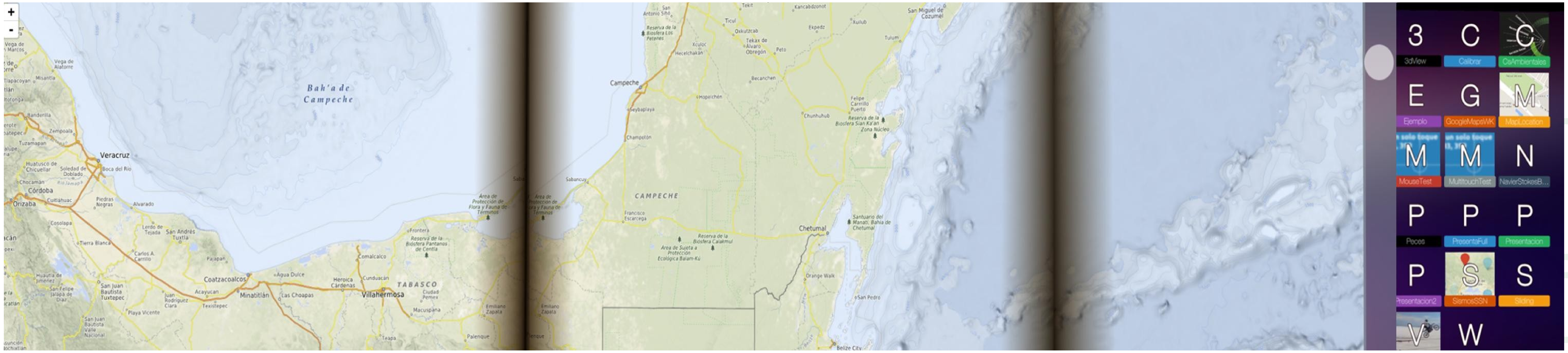
General Idea Step 2 & 3: Split & Darken

QtQuick Tree as a Texture

1) Put **whole scene as ShaderEffectSource**

Here be dragons!

Found a couple of QTBUG's, like Webkit refused to render... now solved



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Software (3/3).

The User Interface, Edge Blending using QtQuick and GLSL

Bonus points: We implemented generic homography warping

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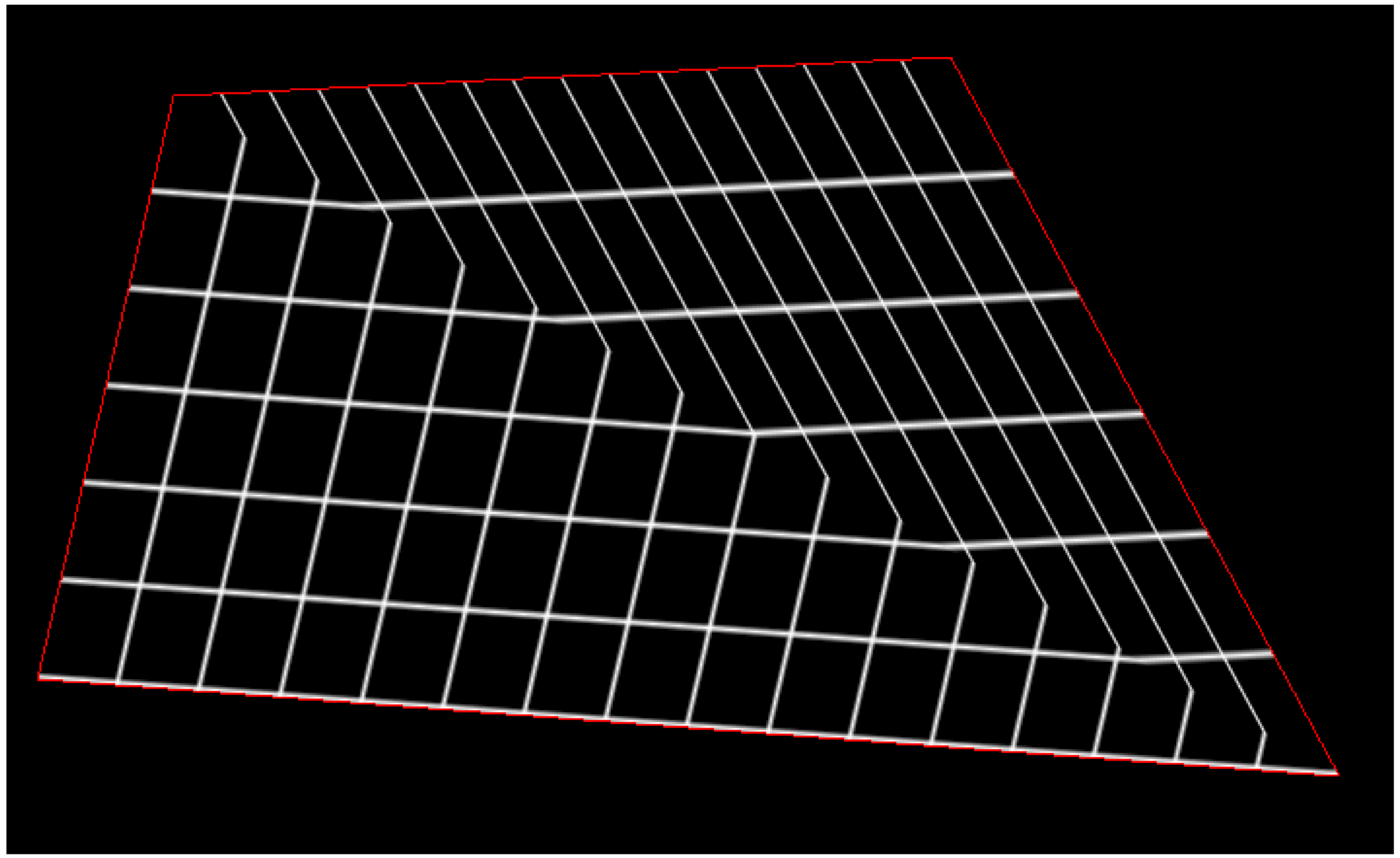
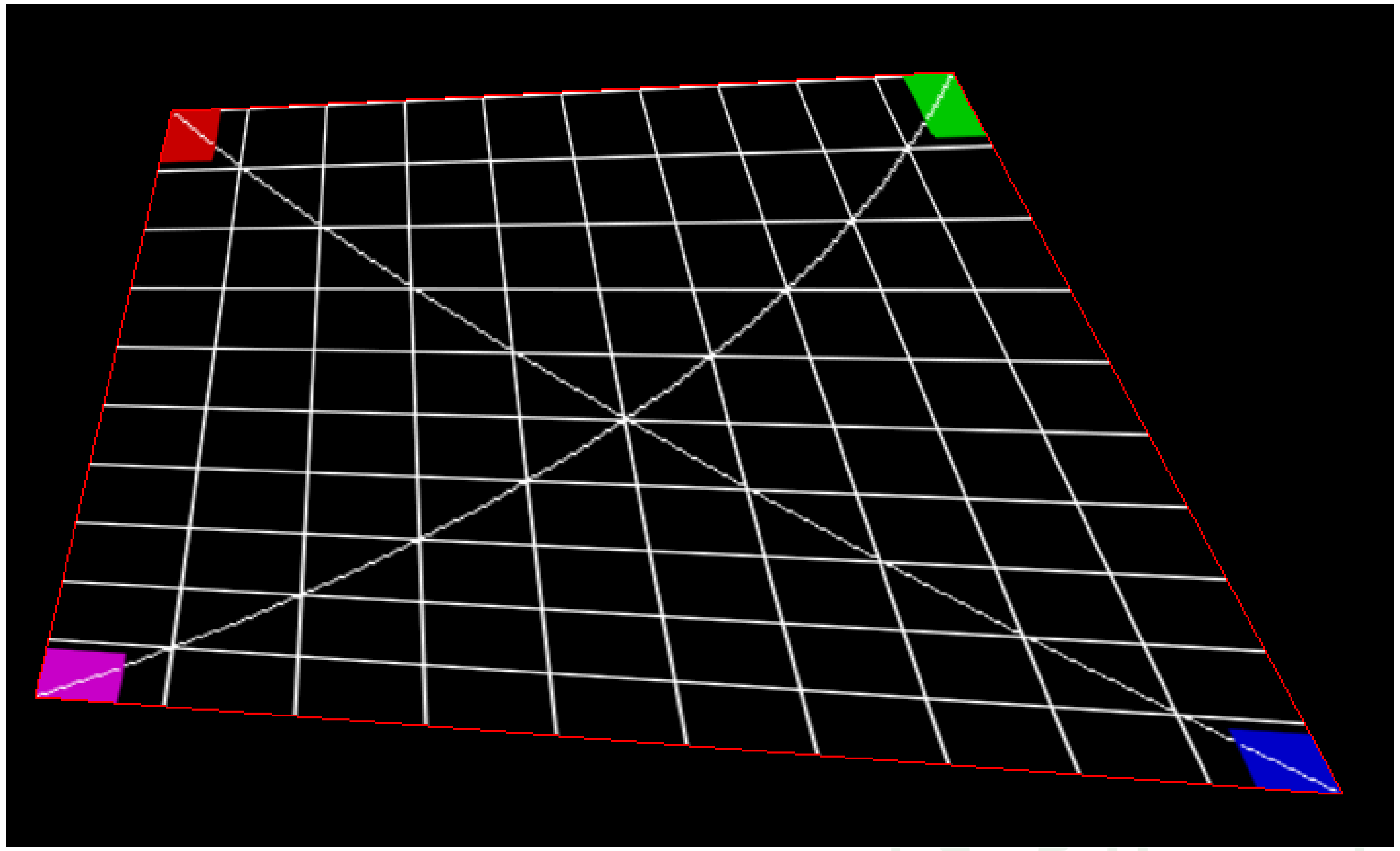
Software (3/3).

Warp each image, because axis-**aligning projectors is a nightmare**



Simple Quad Warping
Ugly transformation, incorrect coords



Homography Warping
Perfect perspective correction

Building The Largest Multitouch Screen in Latin America

Software (3/3).

Bah'a de Campeche
Veracruz
Córdoba
Orizaba
Coatzacoalcos
Minatitlán
Villahermosa
TABASCO
Campeche
CAMPECHE
Chetumal
Belize City
3dView
Calibrar
CsAmbientales
Ejemplo
GoogleMapsWK
MapLocation
MouseTest
MultitouchTest
NavierStokesB...
Peces
PresentaFull
Presentacion
Presentacion2
SismosSSN
Sliding

Before homography, projectors carefully aligned

Software (3/3).

Bahía de Campeche
Veracruz
CAMPECHE
TABASCO
Chetumal
3
C
E
G
M
N
P
S
V
W

After homography, projectors awfully aligned, ShaderEffect fixes it

Software (3/3).

The User Interface, Edge Blending

General Idea Step 2 & 3

QtQuick Tree as a Texture

1) Put whole scene as ShaderEffectSource
2) Render just the needed slice using ShaderEffect (N-times)
3) While being there, darken edges
4) Bonus: Homography warping
5) **Finally**: Put projectors however fits your taste, align them with QtQuick

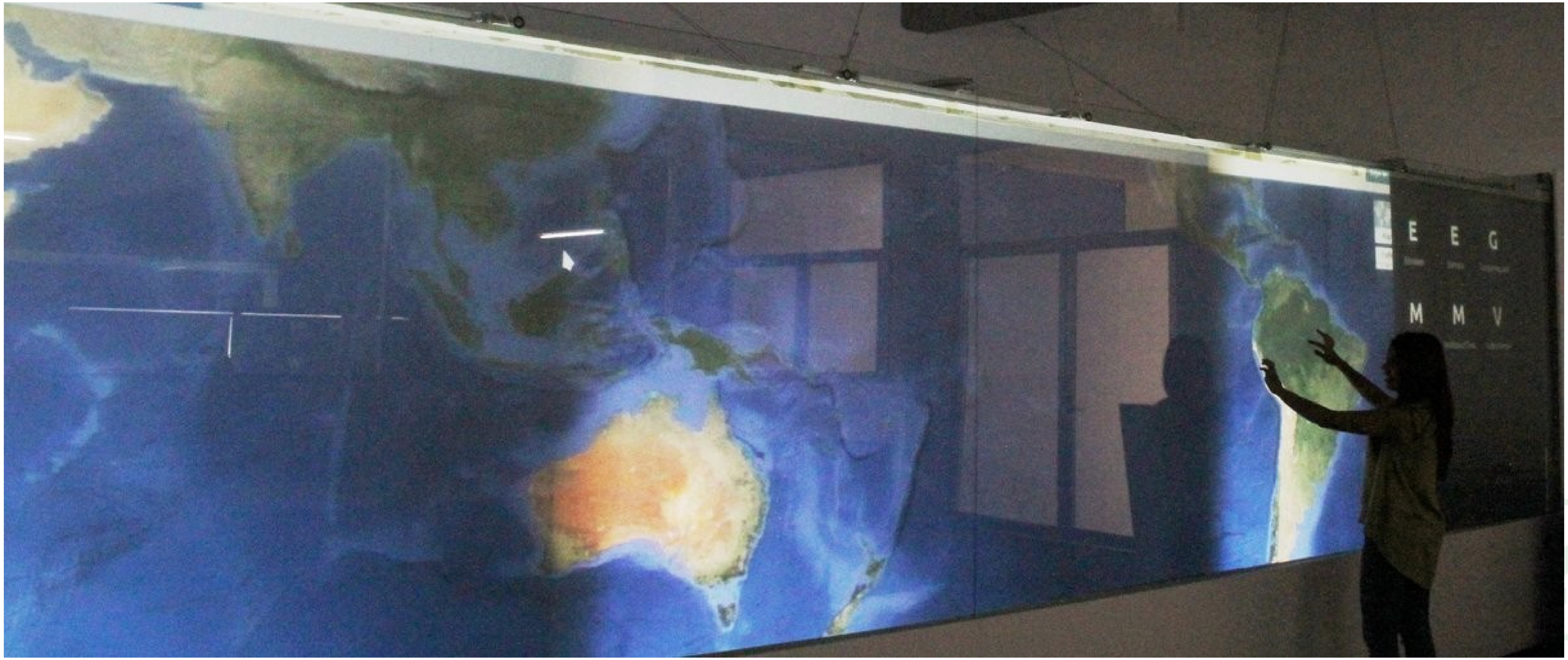
Software (3/3).

The User Interface, Edge Blending

Building The Largest Multitouch Screen in Latin America

Software (3/3).

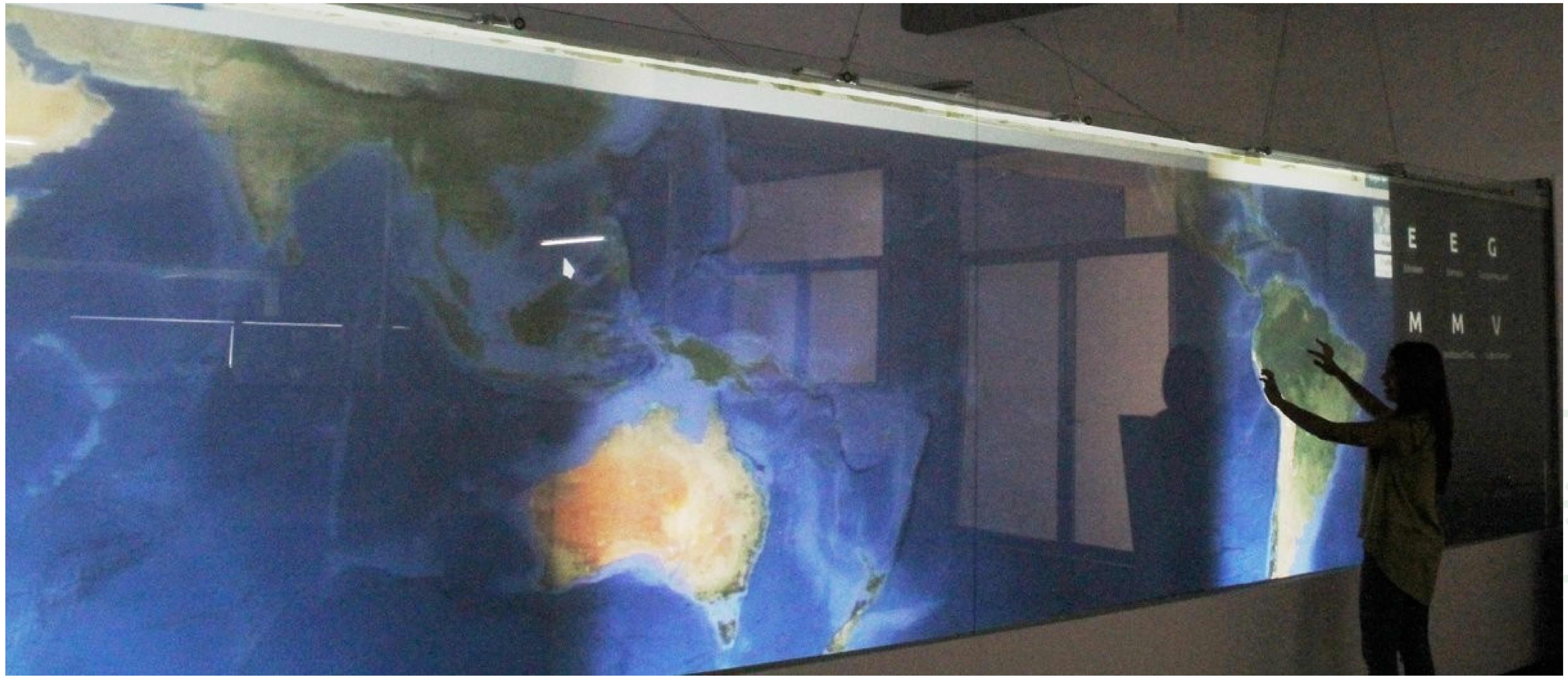
The User Interface, Edge Blending RESULTS



Software (3/3).

The User Interface, Edge Blending RESULTS

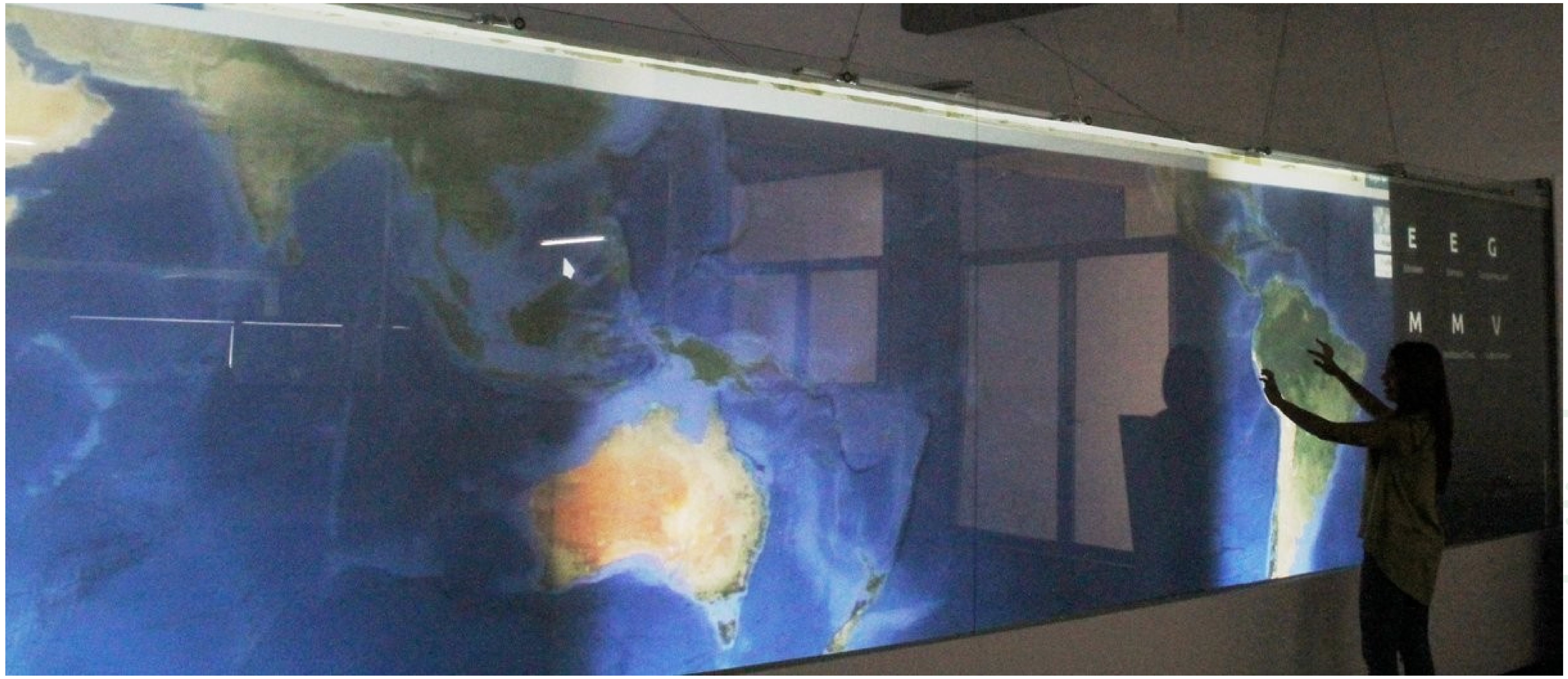
Really hard to see any imperfections



Software (3/3).

The User Interface, Edge Blending RESULTS

Warp carefully and get a perfect image



Building The Largest Multitouch Screen in Latin America

Software (3/3).

The User Interface

So, how was it, remember?

General Idea:

1) Overlap projector instead of align
2) Split projector segments
3) Darken edges to compensate brightness (**and warp**)
4) Rewarp mouse/touch coordinates
5) …
6) Fun

Just one last step to do!

dge blending using commodity projectors
y Paul Bourke
ttp://paulbourke.net/texture_colour/edgeblend/

Building The Largest Multitouch Screen in Latin America

Software (3/3).

The User Interface

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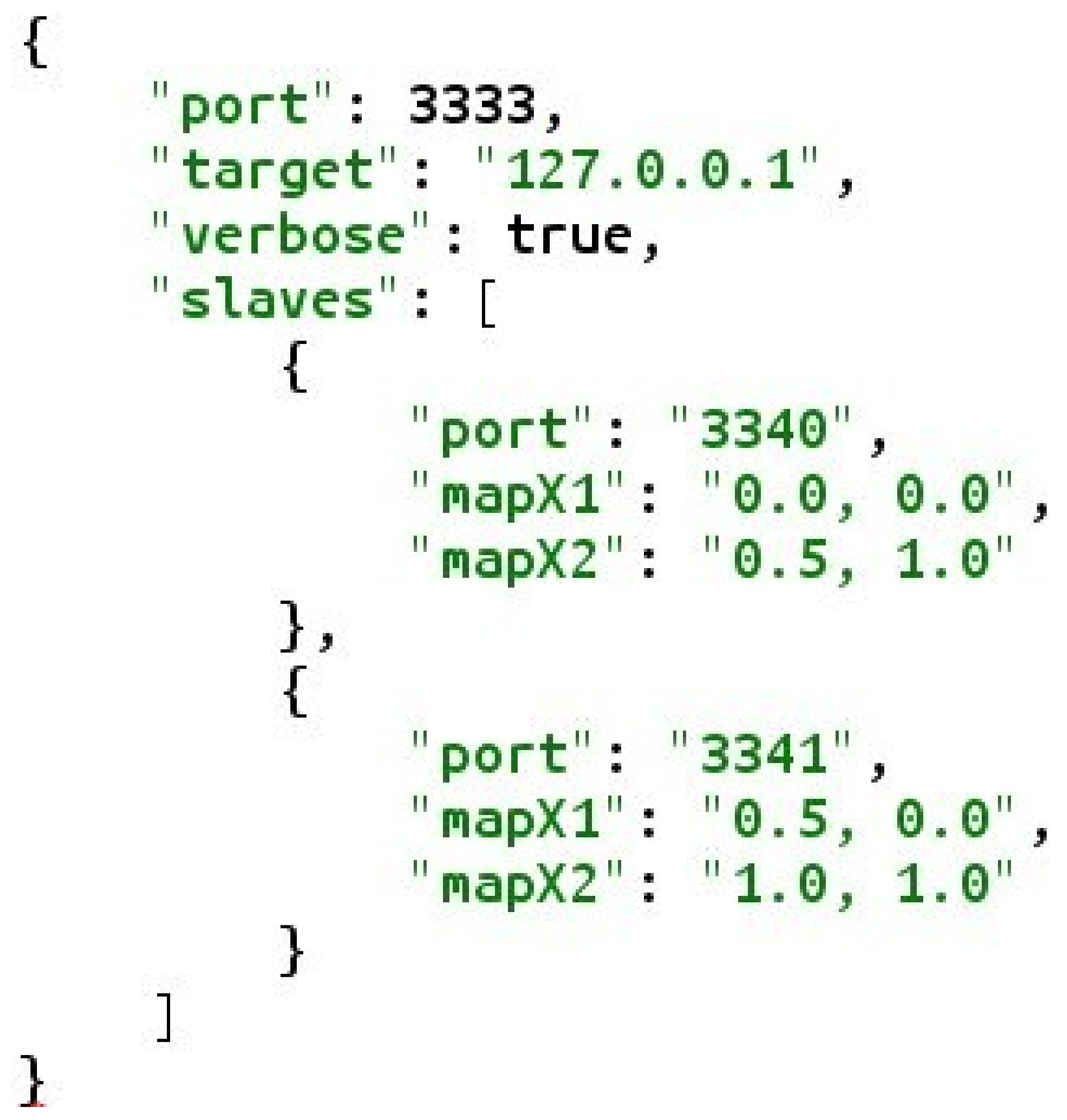
Software (3/3).

The User Interface

- Last step is easy, we just used coordinate remapping
- Our multiplexor, “tarengo” did it automatically
- Define a TUIO tracker mapping at slices
- It works



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    "target": "127.0.0.1",
    "verbose": true,
    "slaves": [
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            "port": "3340",
            "mapX1": "0.0, 0.0",
            "mapX2": "0.5, 1.0"
        },
        {
            "port": "3341",
            "mapX1": "0.5, 0.0",
            "mapX2": "1.0, 1.0"
        }
    ]
}
```

Building The Largest Multitouch Screen in Latin America

Software (3/3).

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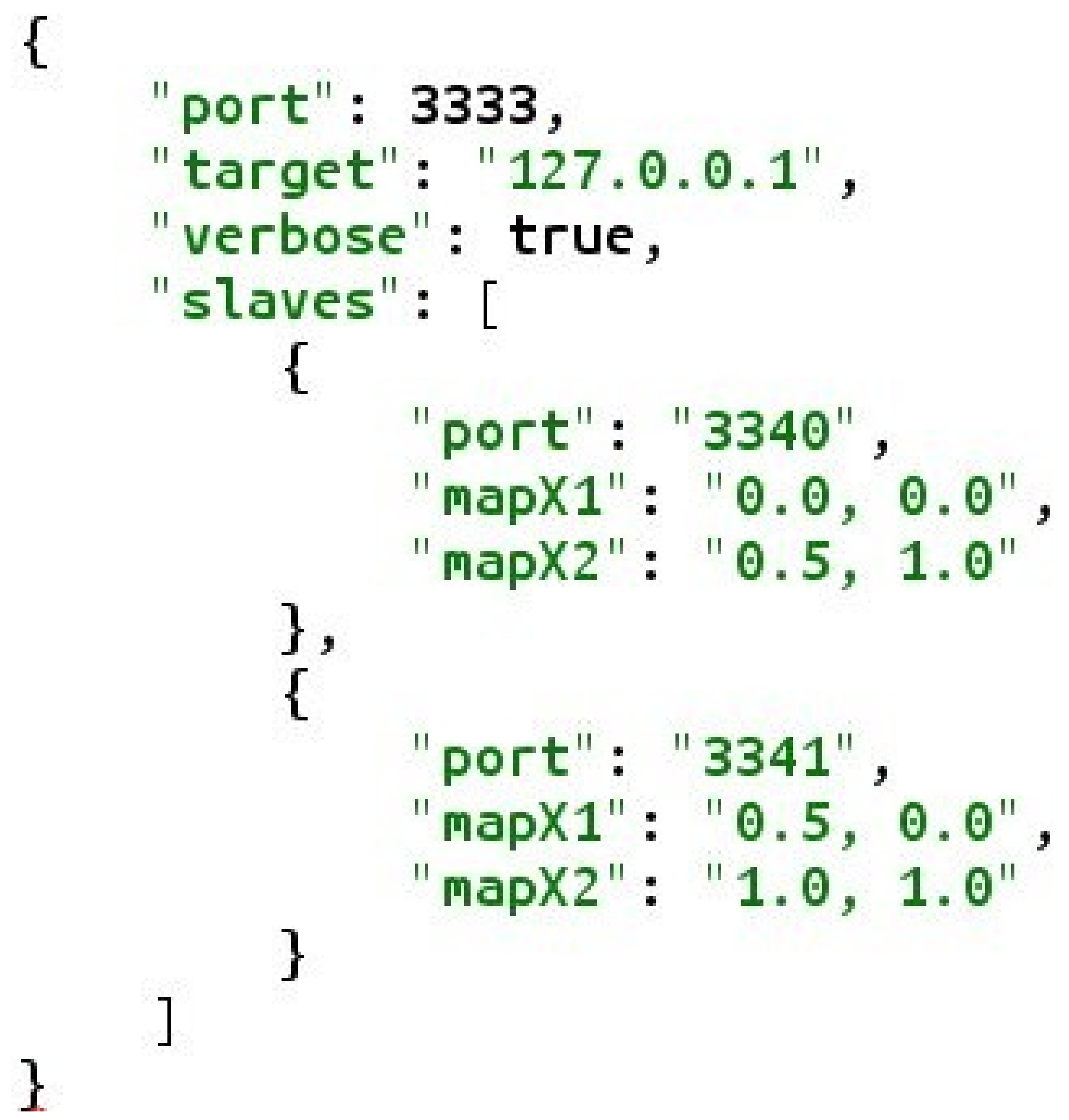

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… but that's TUIO network traffic,

how does Qt handles TUIO?

Software (3/3).

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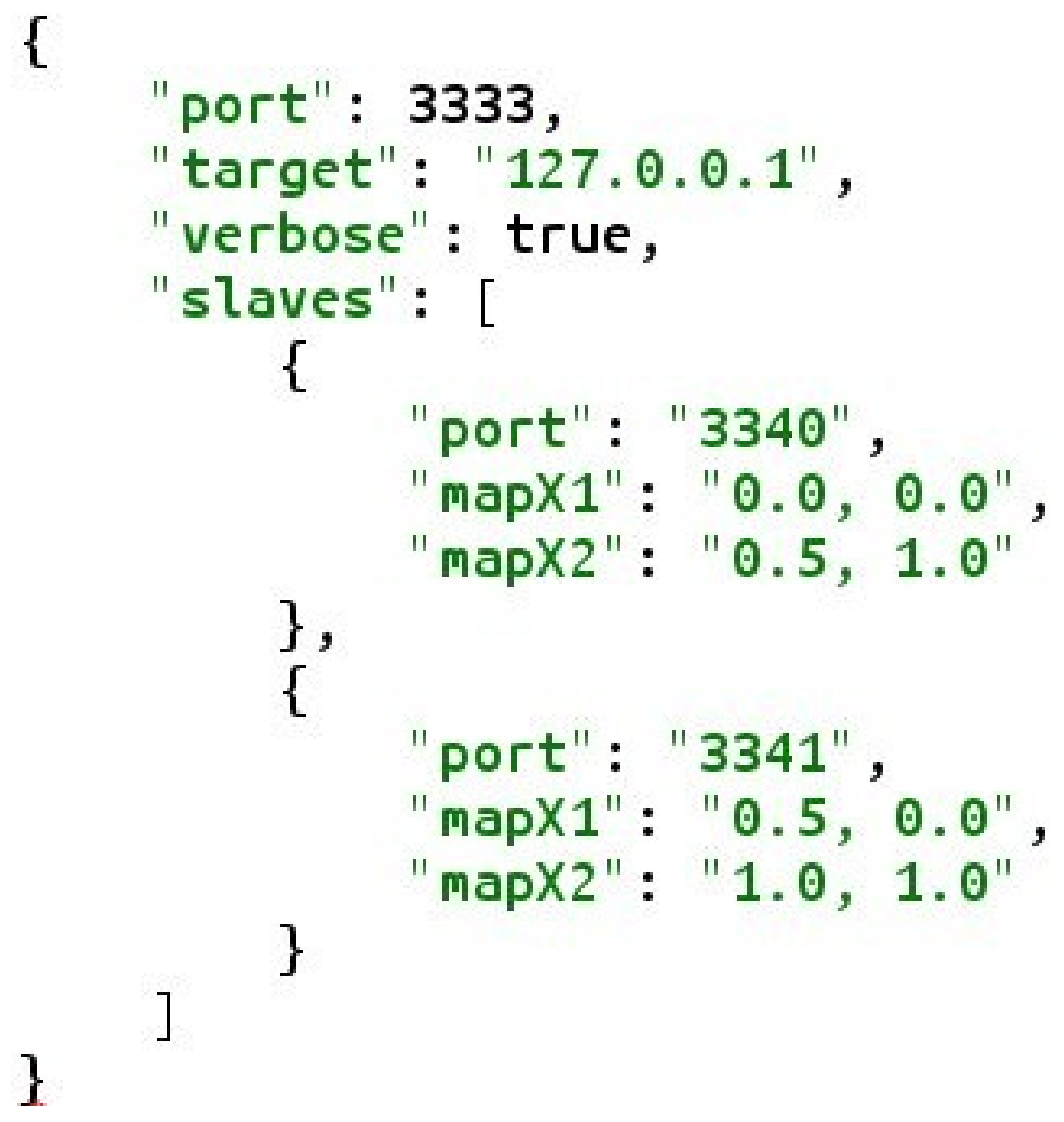

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how does Qt handles TUIO?

Qt Platform Abstraction Plugin

Building The Largest Multitouch Screen in Latin America

Software (3/3).

The User Interface is Native Touch

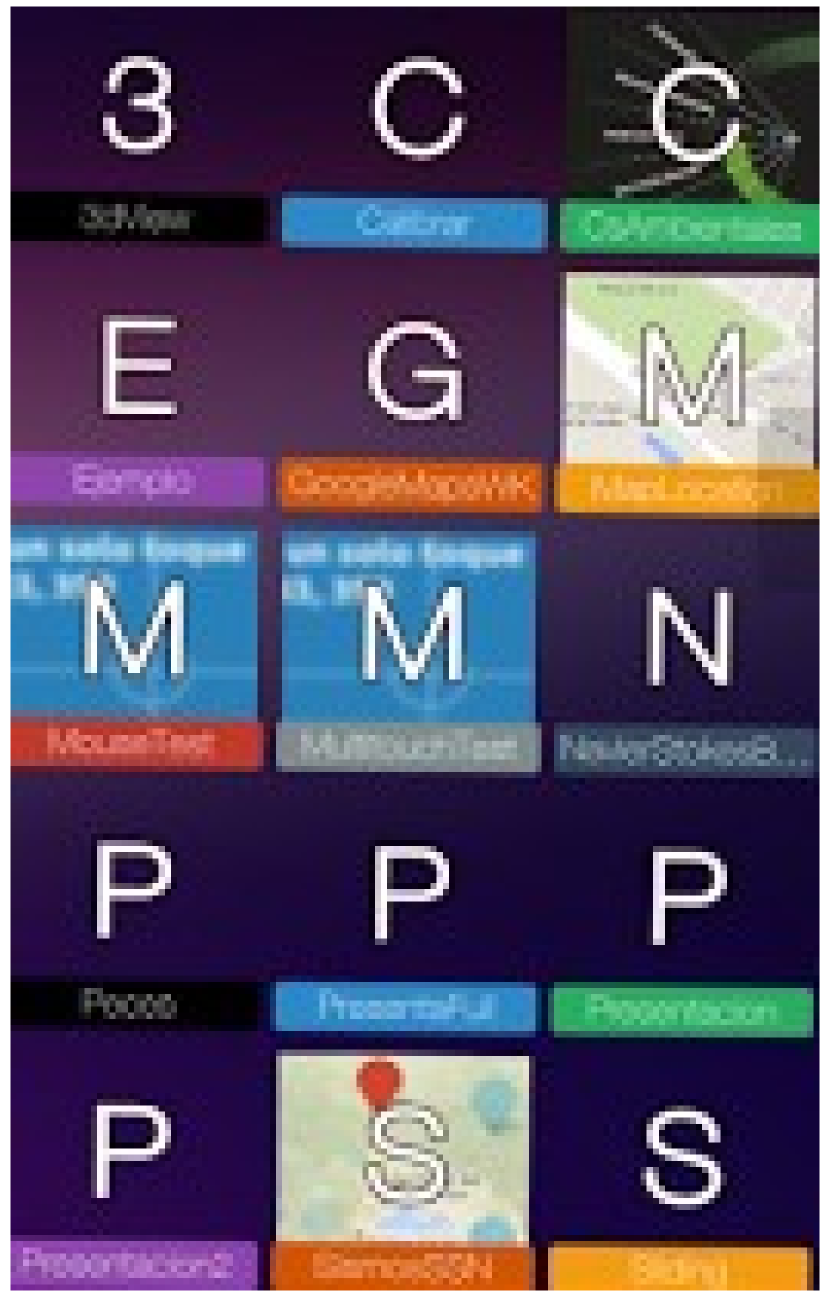
- Platform Abstraction Plugin
- Listen for TUIO input at launch
- Setup a TouchDevice
- Map TUIO Cursors almost without effort, they map nicely to QTouchPoints

- And then PinchArea, MultipointArea and friends work perfect!

Building The Largest Multitouch Screen in Latin America

Resume:

1. Create QtQuick UI with Qt Creator
2. Copy the folder to remote server (Samba)
3. Use it



DEVELOPER DAYS 2014 EUROPE

Building The Largest Multitouch Screen in Latin America

Thank you

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