Tracking Library for the Web

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Outline

1 Introduction

2 Basic concepts
- Web
- Visual tracking
- Visual tracking on the web

3 Tracking library for the web

4 Results and evaluation
- Color tracking algorithm
- Rapid object detection (Viola Jones)
- Markerless tracking algorithm

5 Conclusions

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Motivation

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- Entertainment solutions are gaining space on the web
- Vision is an accurate and low-cost solution

Problem definition

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- Video processing requires high computational complexity
- JavaScript is a language interpreted by all web browsers
- Interpreted languages have limited computational power

Objectives

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- Accelerate the use of visual tracking in commercial products

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- Accelerate the use of visual tracking in commercial products
- Implement a cross-platform tracking library for the web

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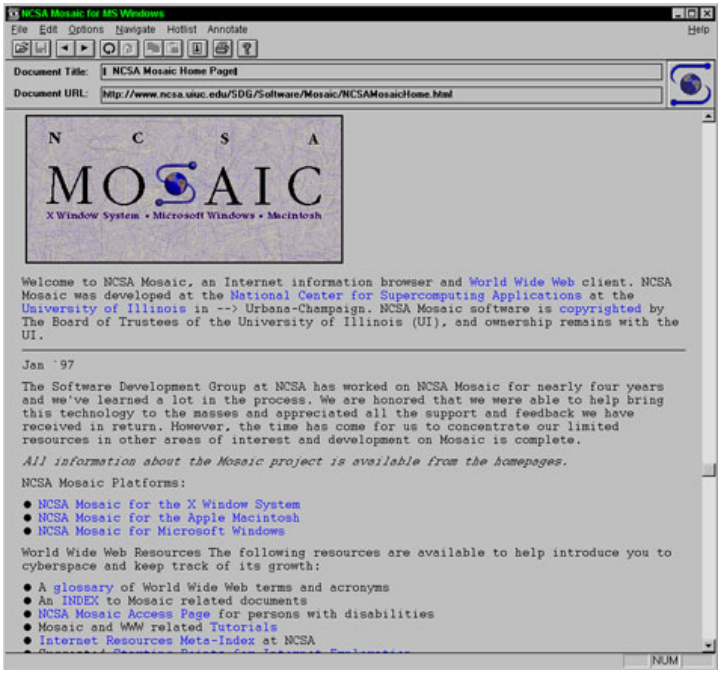
The beginning of the web



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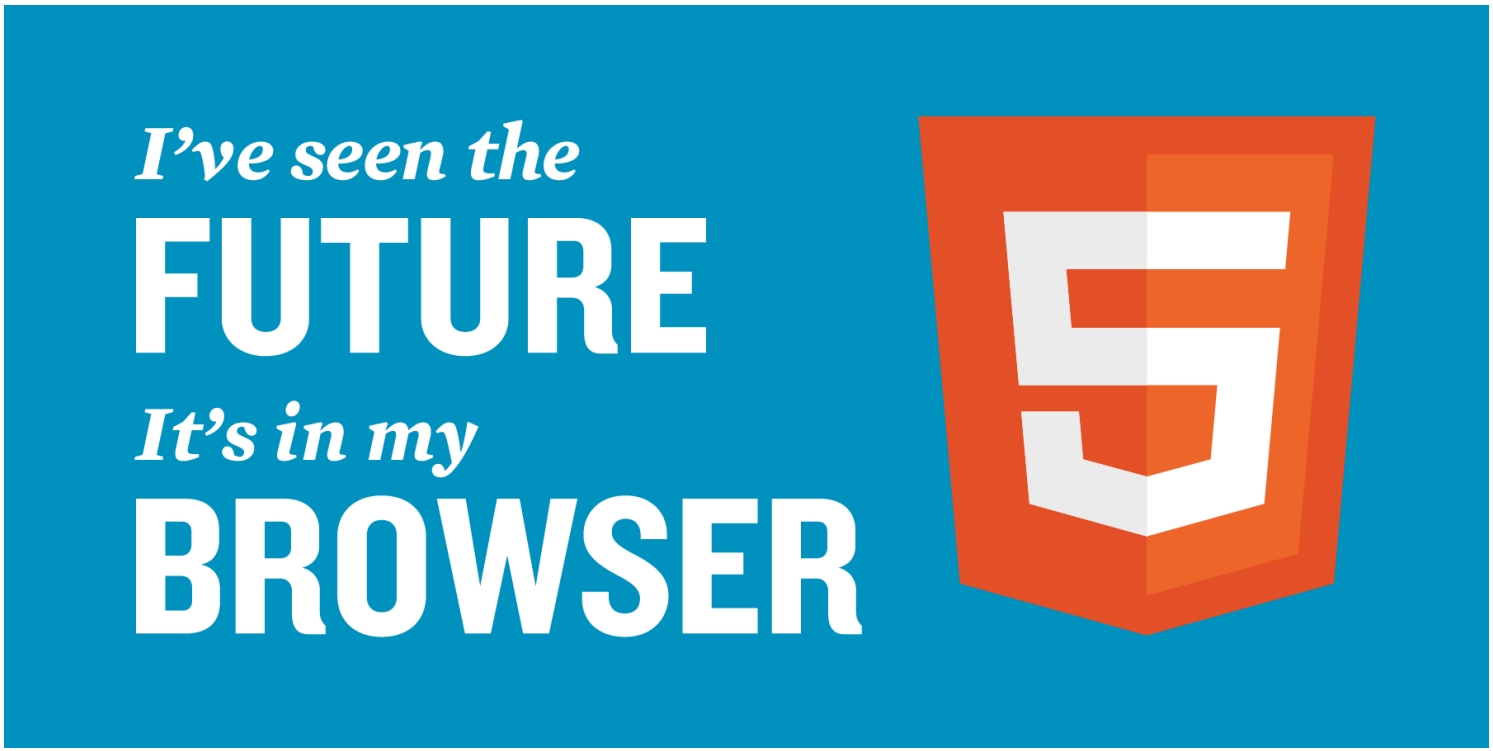
- In 1994, the World Wide Web Consortium (W3C) was founded
- Companies were able to contribute to the W3C specifications
- Today's web is a result of the ongoing efforts of an open web

The modern web



The modern web

- Contributions transformed the web in a growing universe

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- Videos, audio, photos, interactive content, 3D graphics

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- Contributions transformed the web in a growing universe
- Videos, audio, photos, interactive content, 3D graphics
- Processed by the Graphics Processing Unit (GPU)
- Without requiring any third-party plugins installation

Browser technologies

Browser architecture

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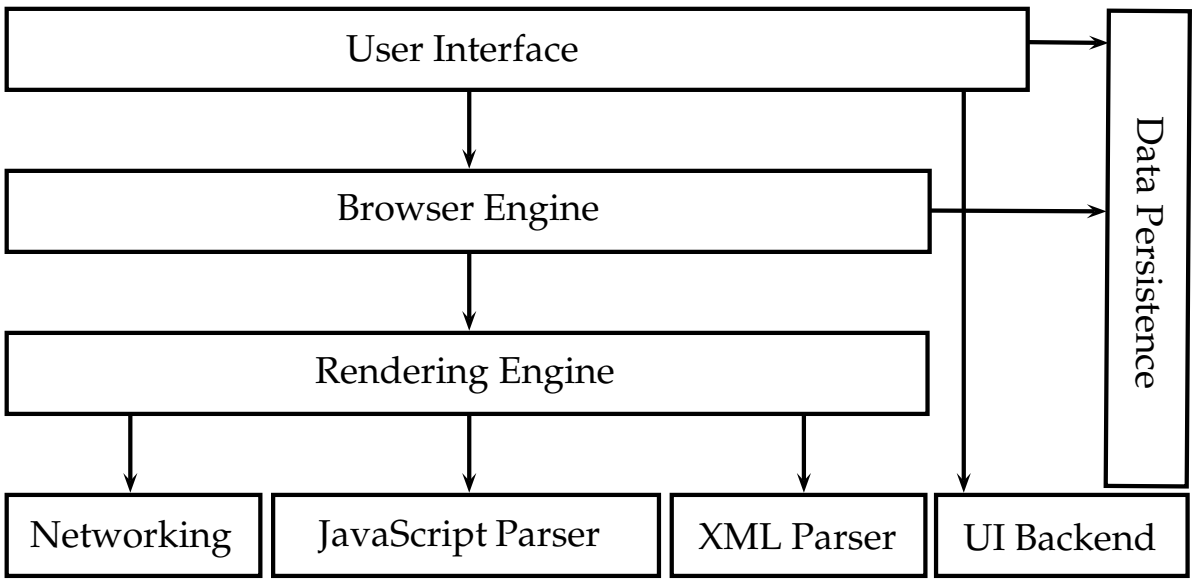
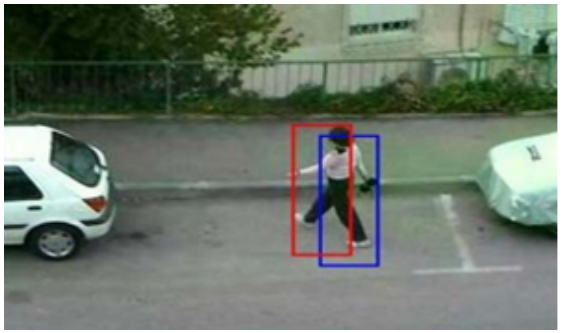


Visual tracking

Tracking an object in a video sequence means continuously identifying its location when either the object or the camera are moving.



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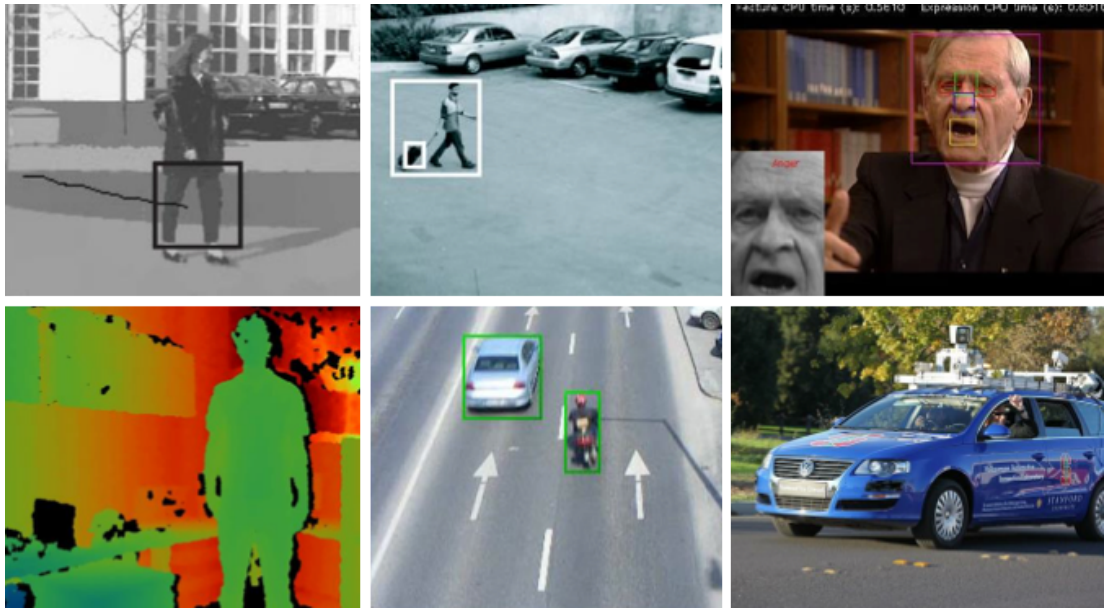
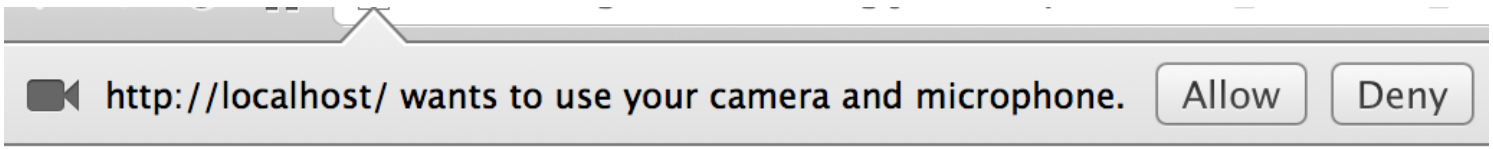


Visual tracking workflow on the web

1. Request user web-cam access



1. Request user web-cam access

getUserMedia

<video>

[0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0 1 1 1]
[r g b a r g b a r g b a r g b a r g b a]

<canvas>

2. Capture web-cam stream

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```
1
2       <script>
3         navigator.getUserMedia({ video: true }, function(localMediaStream) {
4           // Stream captured
5         }, onFail);
6       </script>
```

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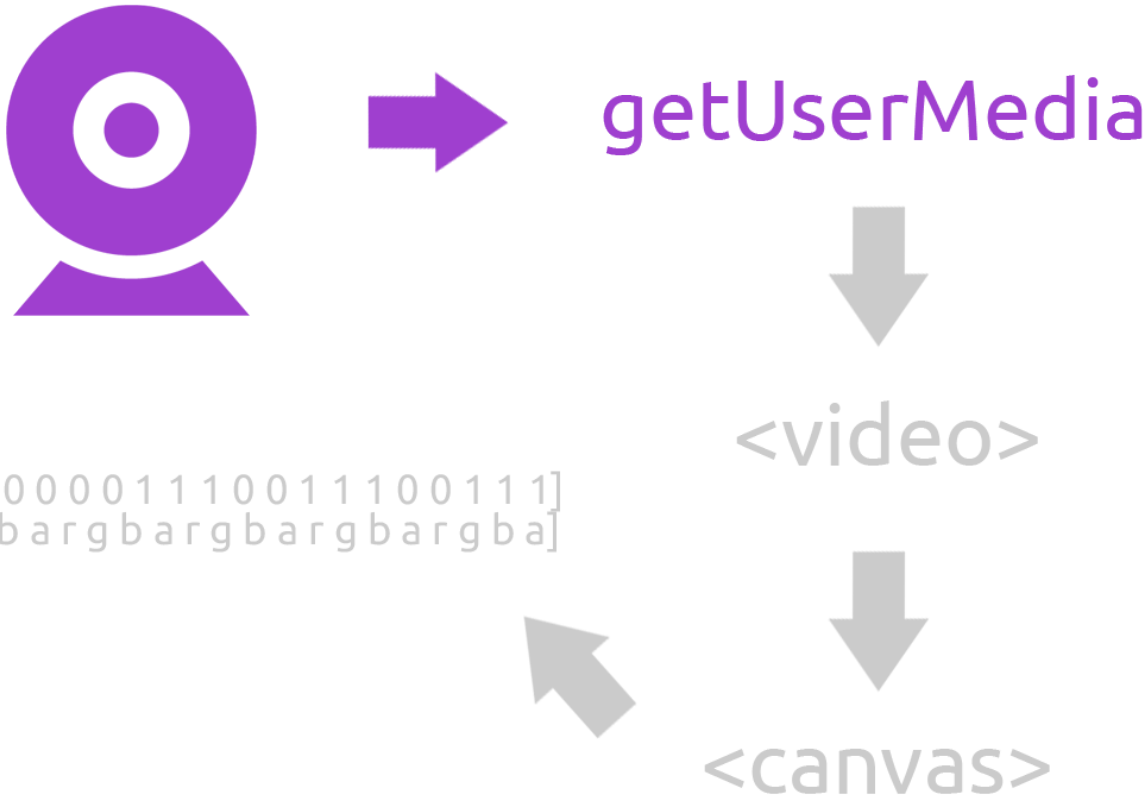

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2     <video autoplay></video>
3     <script>
4       var video = document.querySelector('video');
5       navigator.getUserMedia({video: true}, function(localMediaStream) {
6           video.src = window.URL.createObjectURL(localMediaStream);
7           video.onloadedmetadata = function(e) { alert('Ready to go.') };
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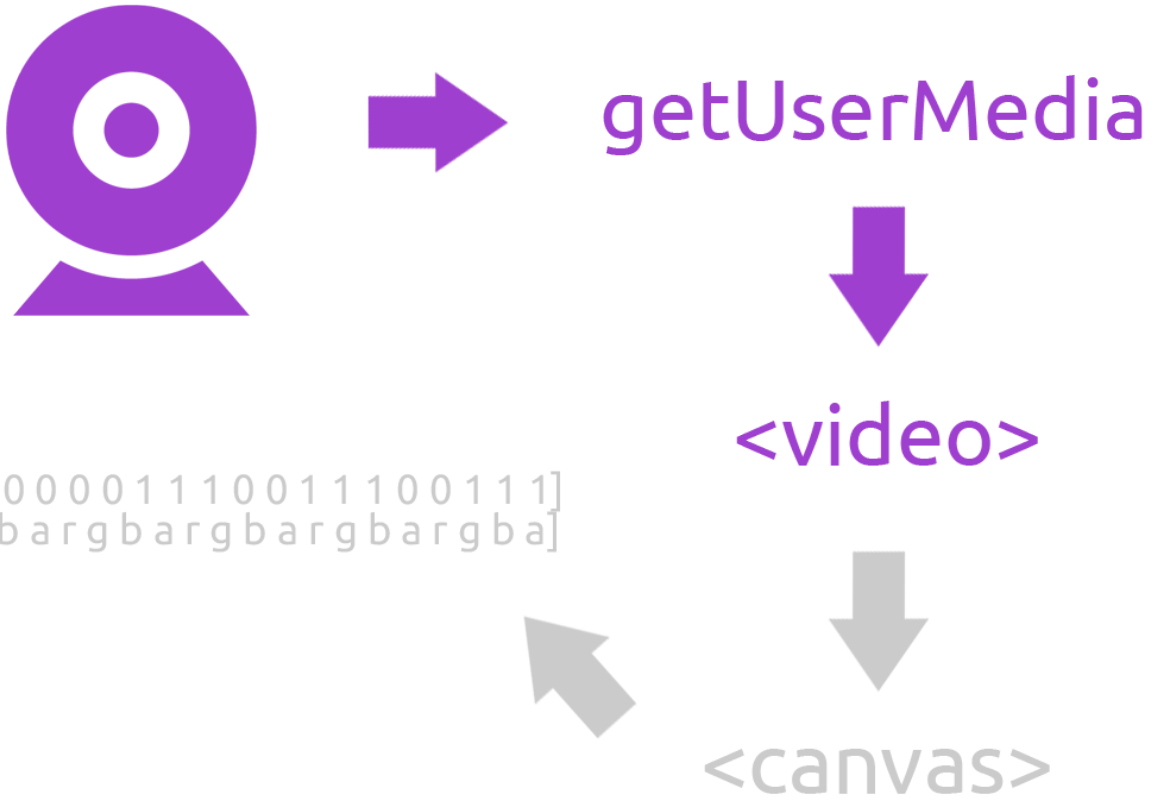
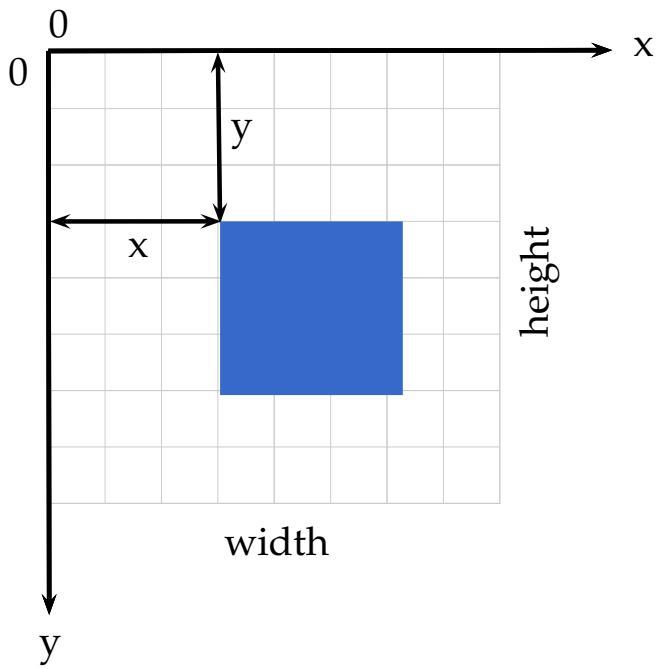


4. Process video data using canvas



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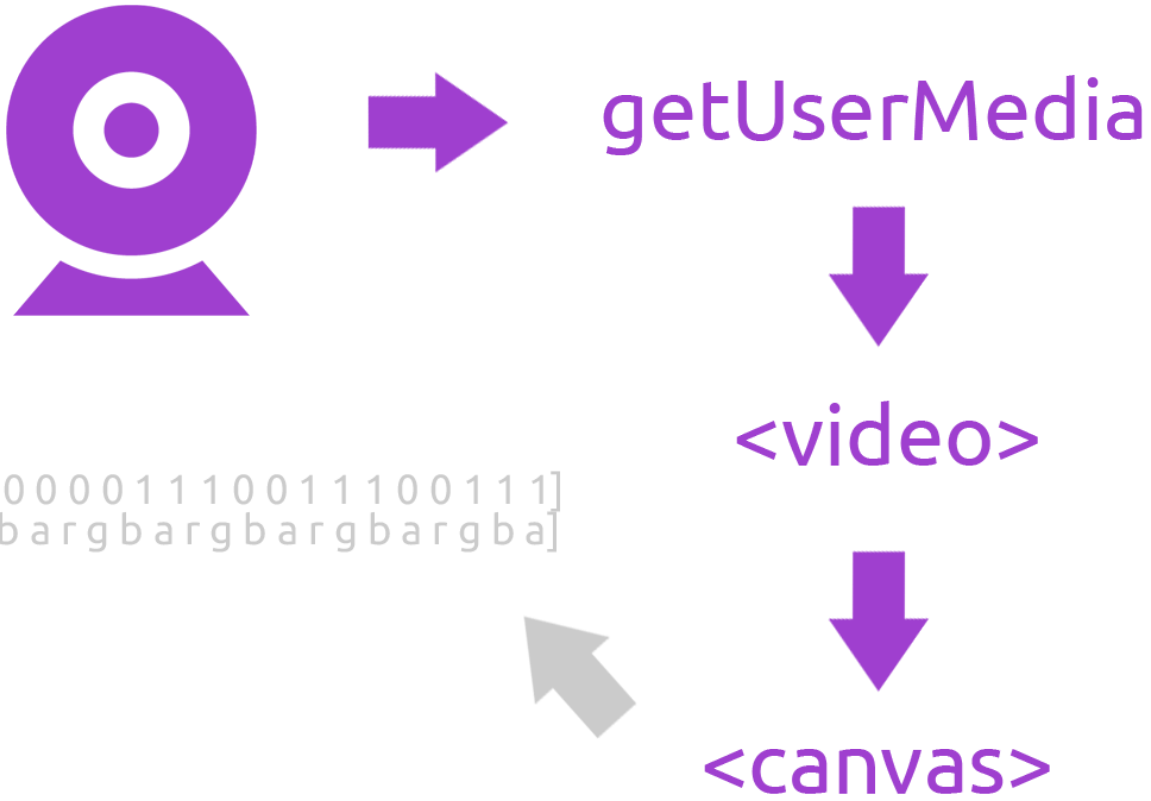
- Introduced as a new element on HTML5
- Resolution-dependent bitmap canvas
- Two-dimensional grid, computer graphics coordinate system
- Can render images, video frames or shapes

4. Process video data using canvas



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- JavaScript-typed arrays access raw binary more efficiently

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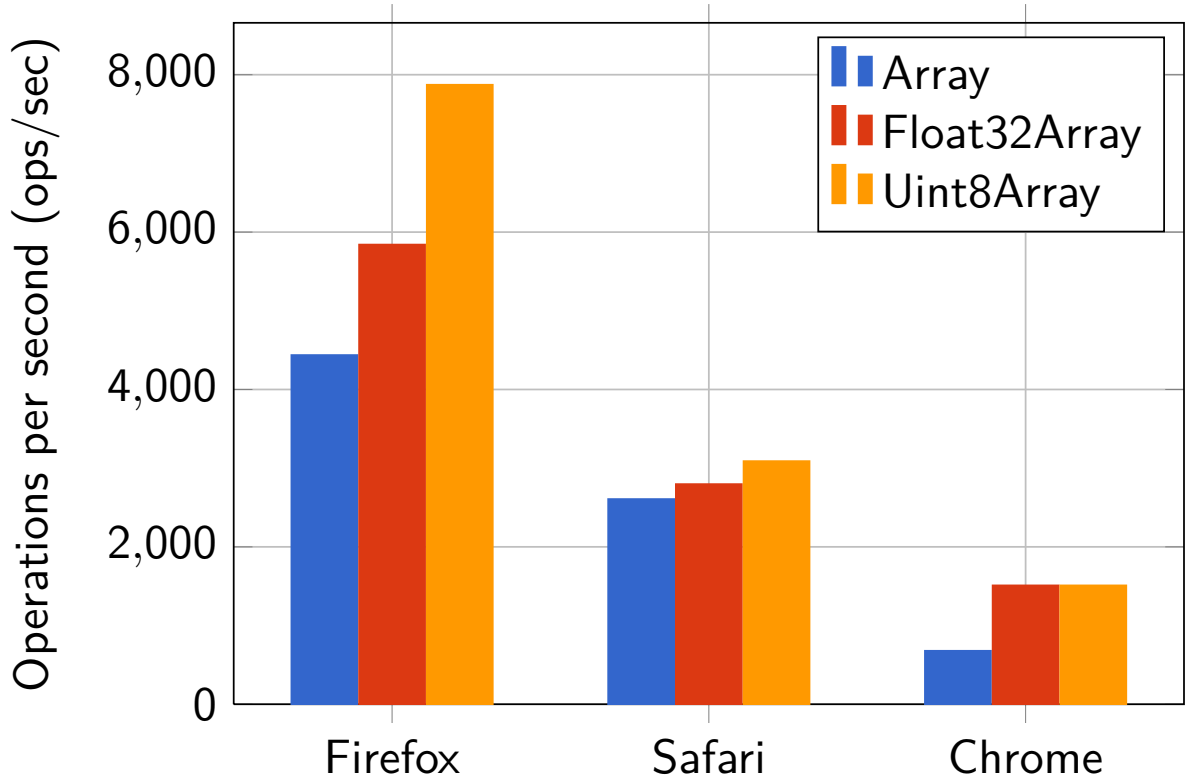

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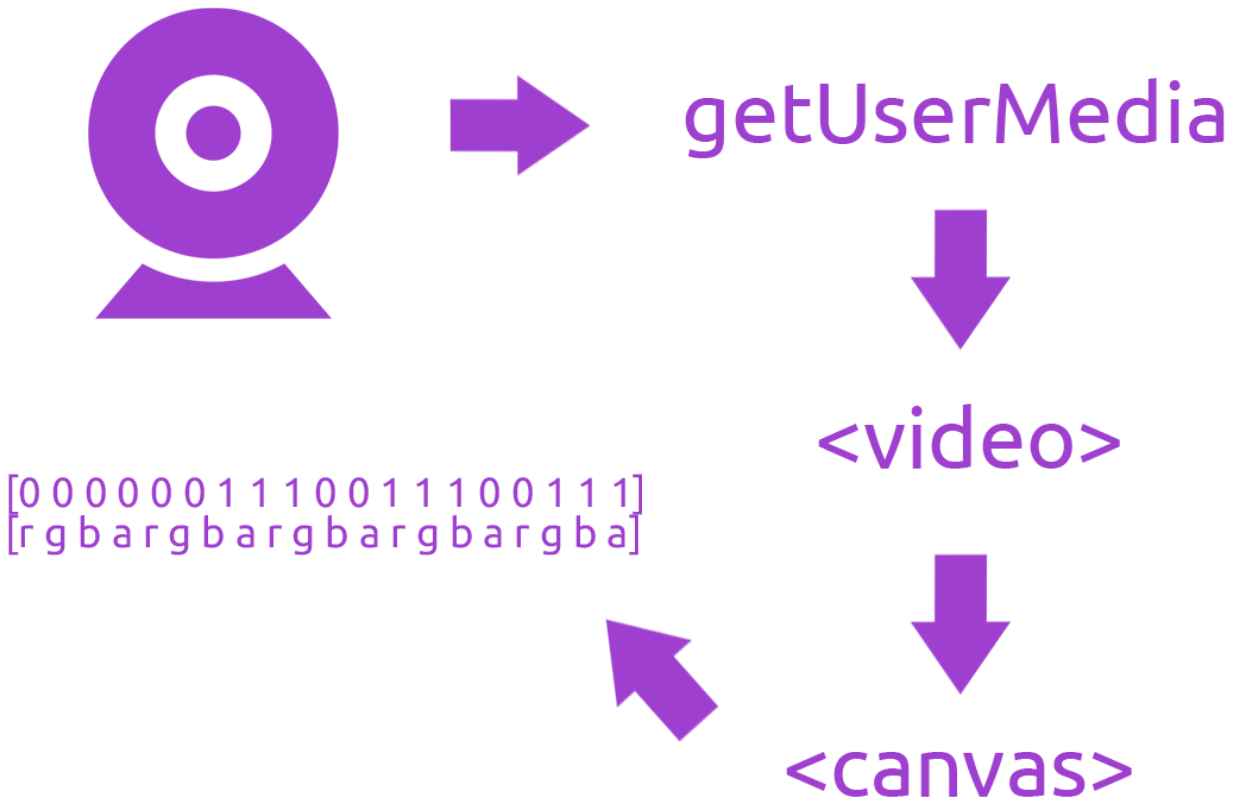

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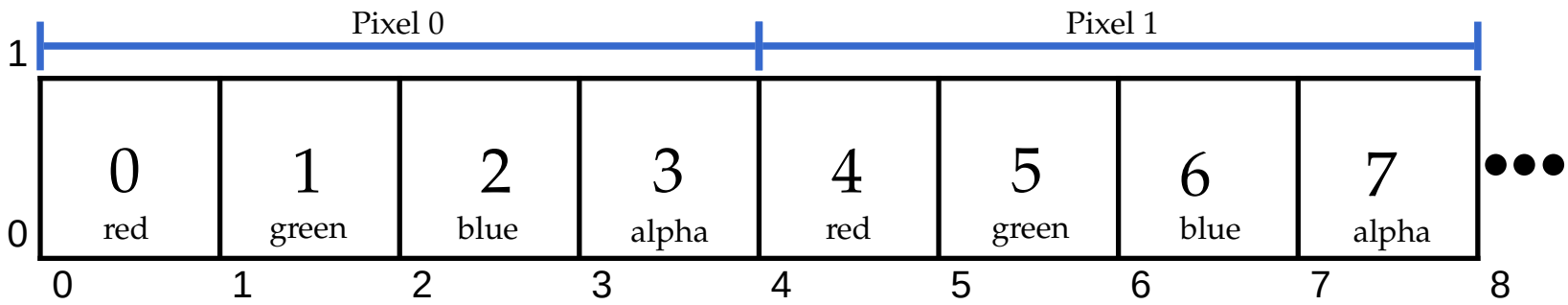
- Canvas raw binary data can be accessed from JavaScript
- Canvas array of pixels, is in row-major order
- Consider the 2×3 array $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$, in row-major order it is laid out contiguously in linear memory as $\begin{bmatrix} 1 & 2 & 3 & 4 & 5 & 6 \end{bmatrix}$.

What is the relation between typed arrays and canvas?



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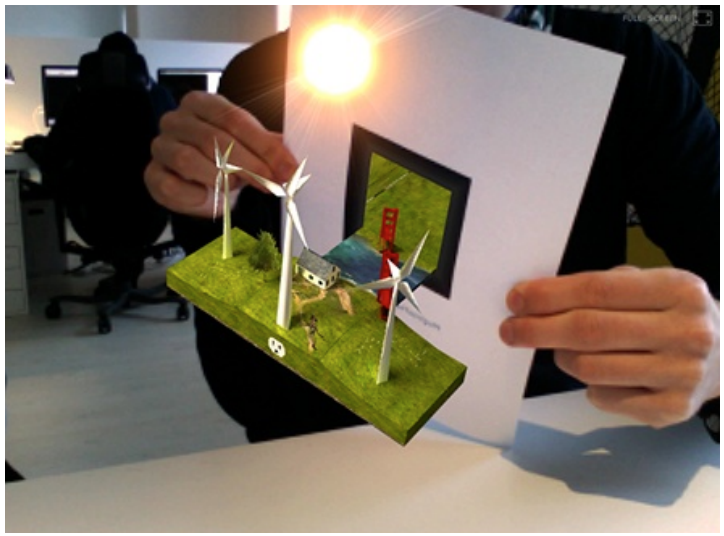
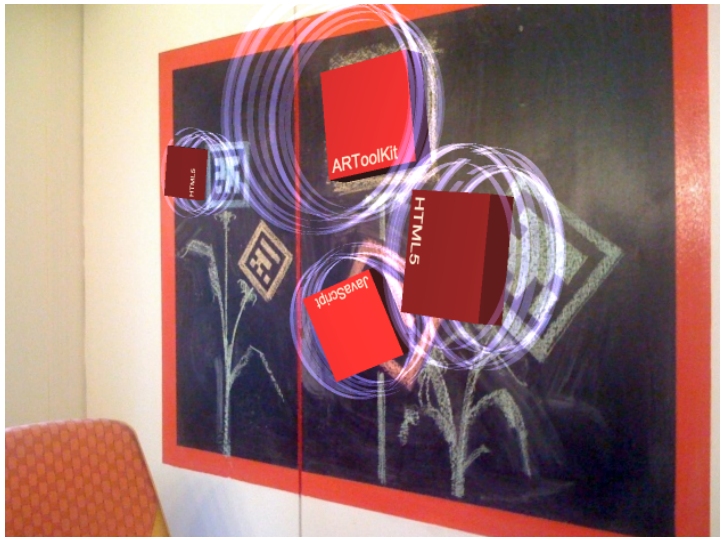
Related work

- FLARToolKit: a port of ARToolKit marker tracking library to ActionScript



Related work

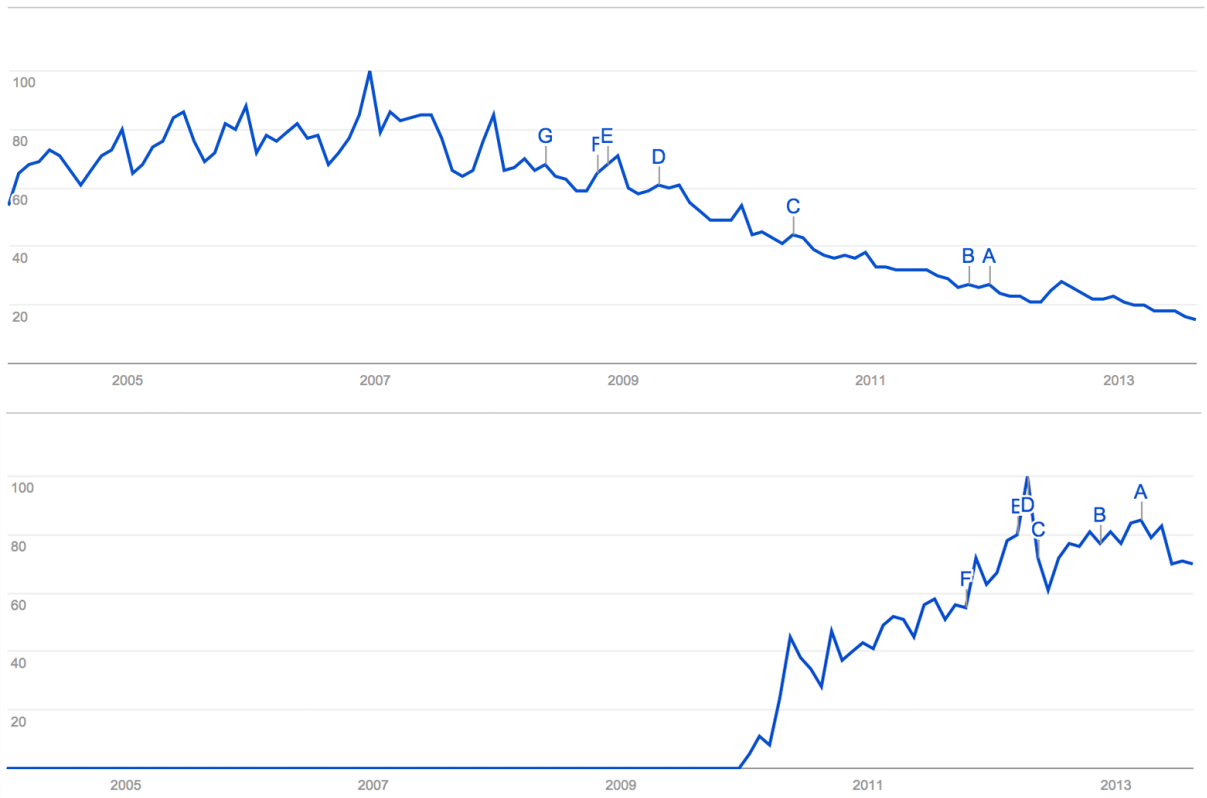
- JSARToolkit: is a JavaScript port of FLARToolKit



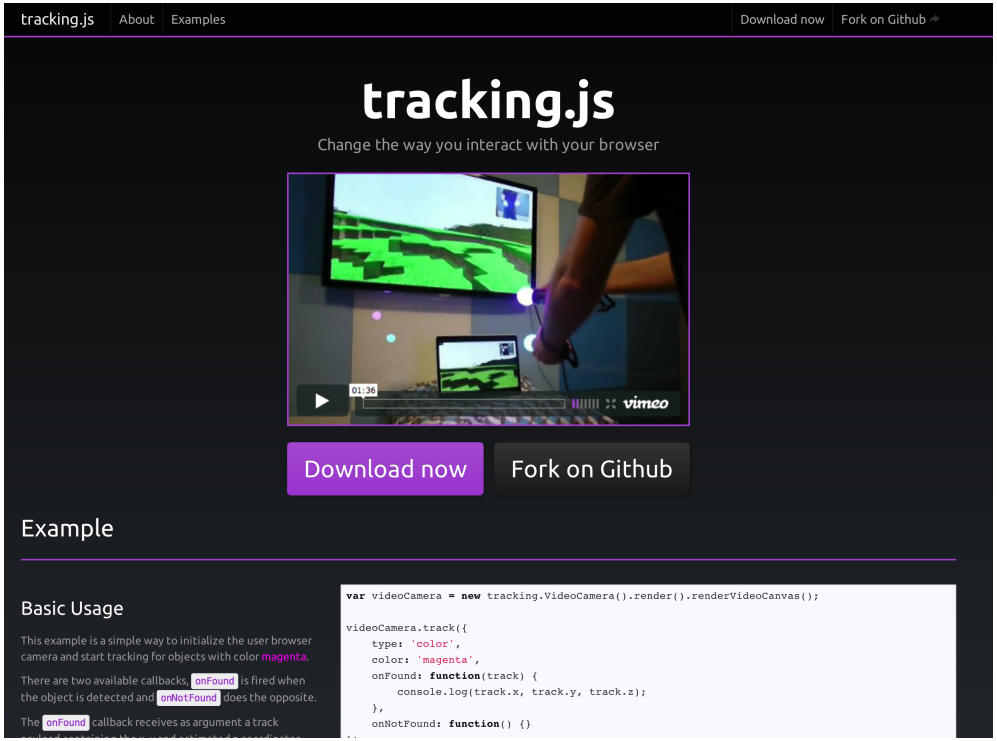
Related work

- Unifeye Viewer: a robust markerless tracking solution for the web to ActionScript

Flash vs HTML5



tracking.js


tracking.js
About
Examples
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tracking.js
Change the way you interact with your browser
01:36
vimeo
Download now
Fork on Github
Example
Basic Usage
This example is a simple way to initialize the user browser camera and start tracking for objects with color magenta.
There are two available callbacks, onFound is fired when the object is detected and onNotFound does the opposite.
The onFound callback receives as argument a track
var videoCamera = new tracking.VideoCamera().render().renderVideoCanvas();
videoCamera.track({
type: 'color',
color: 'magenta',
onFound: function(track) {
console.log(track.x, track.y, track.z);
},
onNotFound: function() {}

tracking.js

Tracking library for the web

Common infrastructure to develop visual tracking applications and to accelerate the use of those techniques on the web in commercial products.

Library features

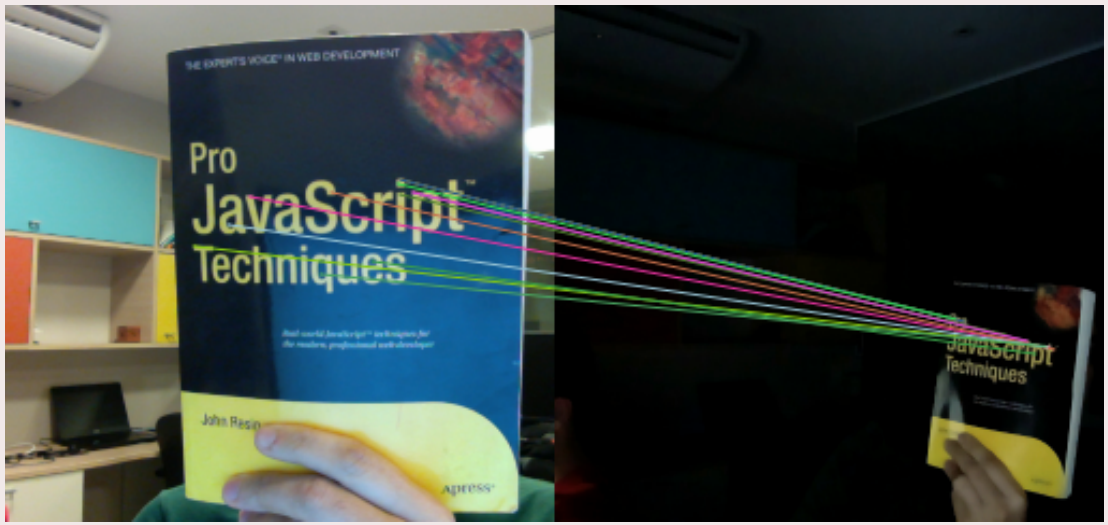
1. Color tracking

Library features

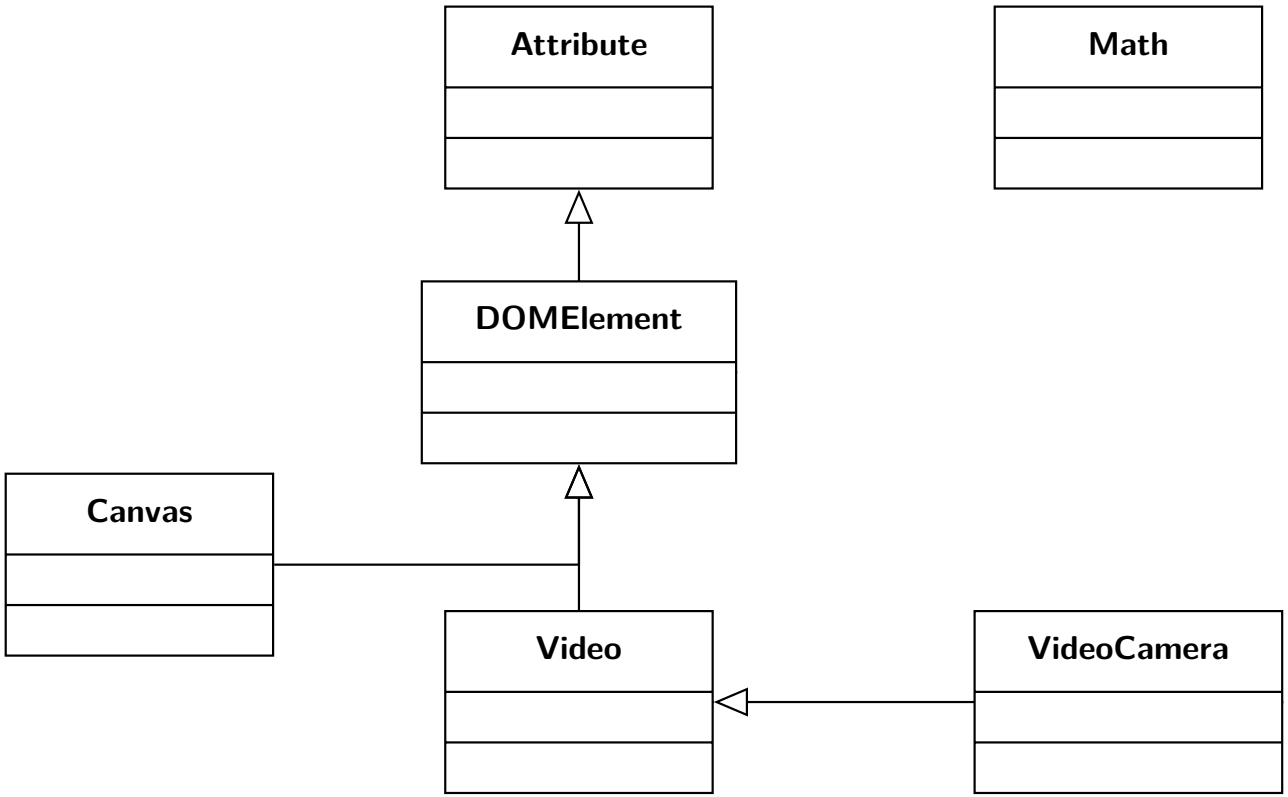
2. Rapid object detection (Viola Jones)

Library features

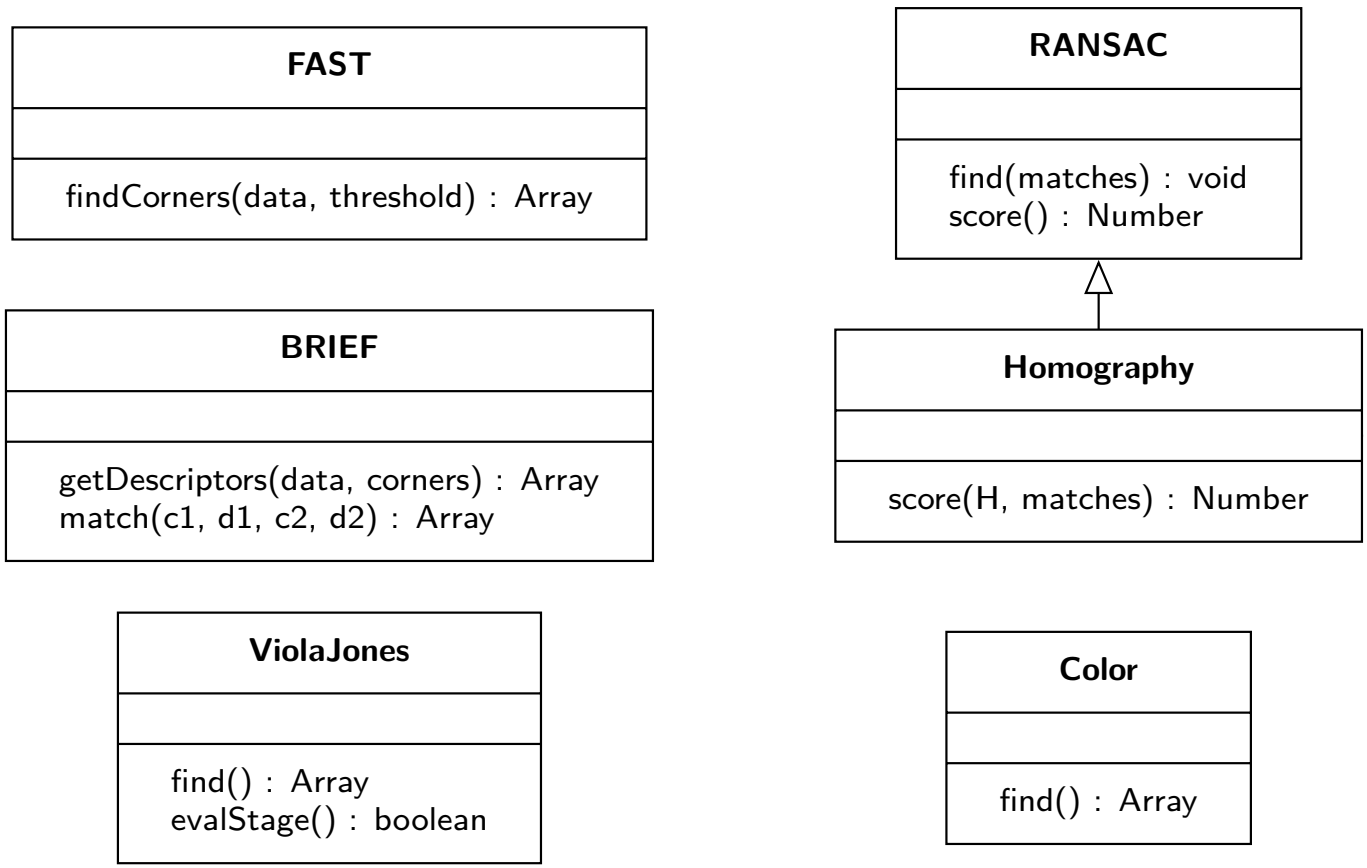
3. Markerless tracking algorithm



Library modules - Base classes



Library modules - Visual tracking classes



Color tracking algorithm

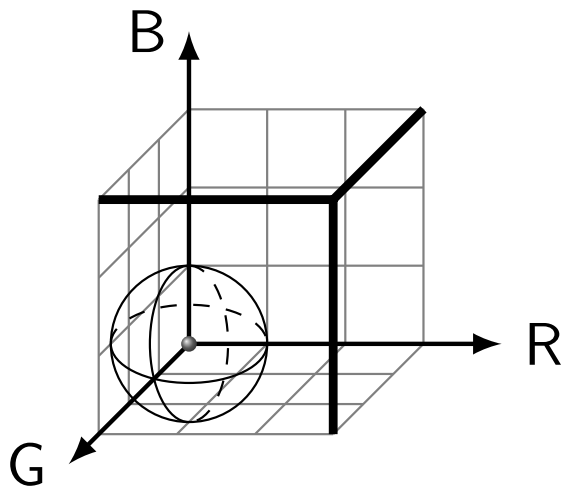
Figure : © http://www.flickr.com/photos/laynecom/8674644879/

Color tracking algorithm

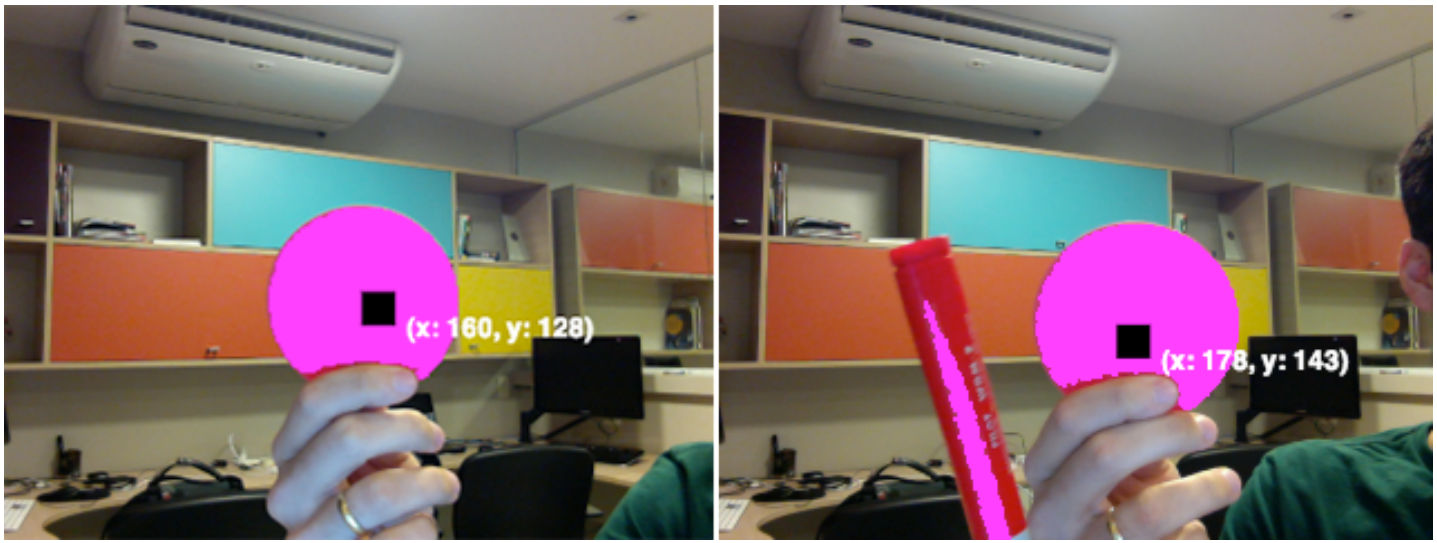
```
1  var videoCamera = new tracking.VideoCamera();
2  videoCamera.track({
3      type: 'color',
4      color: 'magenta',
5      onFound: function(track) {
6          // do your logic here.
7      }
8  });
```

Color tracking algorithm - Color difference evaluation

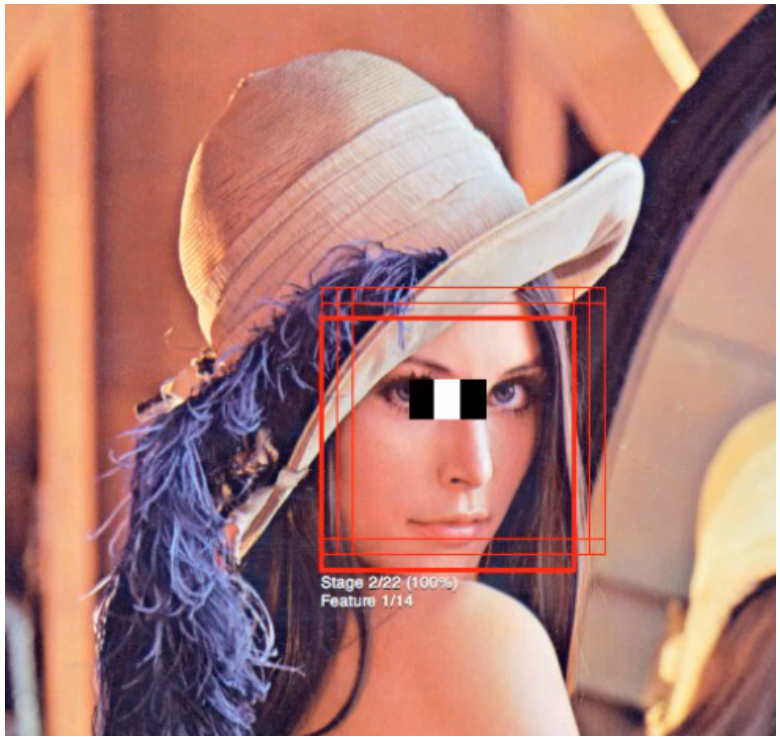
$$\|C_1 - C_2\| = \sqrt{(C_{1,R} - C_{2,R})^2 + (C_{1,G} - C_{2,G})^2 + (C_{1,B} - C_{2,B})^2}$$



Color tracking algorithm - Color blob detection



Rapid object detection (Viola Jones)



Rapid object detection (Viola Jones)

```
1  var videoCamera = new tracking.VideoCamera();
2  videoCamera.track({
3      type: 'human',
4      data: 'frontal_face',
5      onFound: function(track) {
6          // do your logic here.
7      }
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```

Rapid object detection (Viola Jones)

- Robust and extremely rapid object detection

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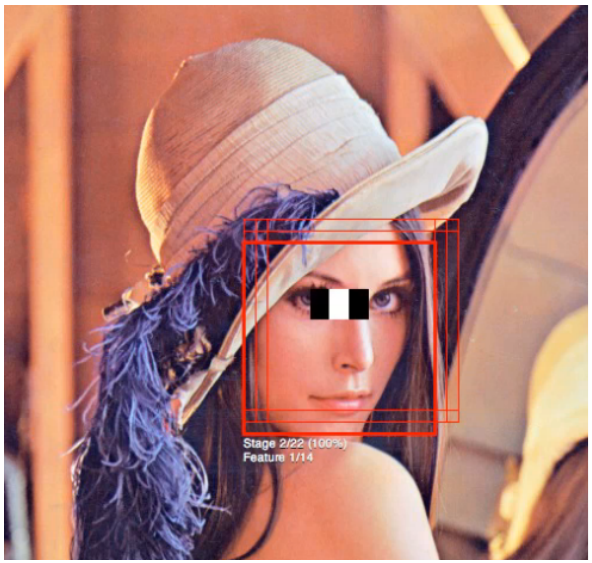
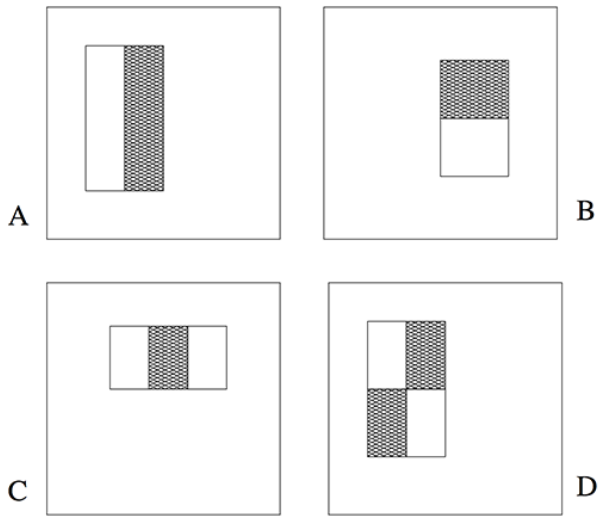
- Became popular mainly because rapid face detection
- A training phase is required
- A scanning detector is what makes the detection

Rapid object detection (Viola Jones)





Rapid object detection (Viola Jones)

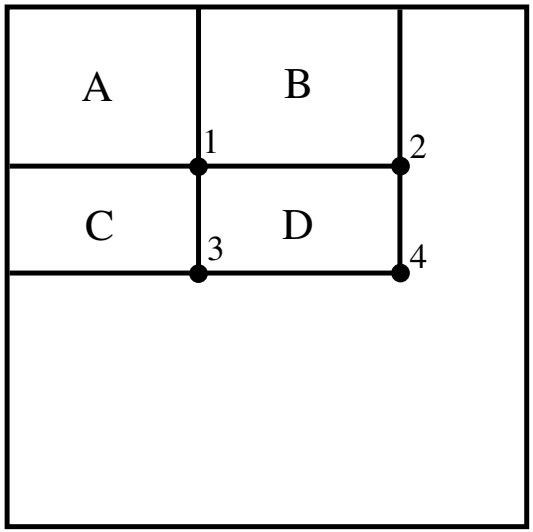
Integral Image

Rectangle features can be computed very rapidly using an intermediate representation for the image which we call the integral image.

The integral image at location x, y contains the sum of the pixels above and to the left of x, y, inclusive

$$ii(x, y) = \sum_{x' \leq x, y' \leq y} i(x', y')$$

Rapid object detection (Viola Jones)



Rapid object detection (Viola Jones)

Scanning detector algorithm

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6. Once the tree is done, group the overlapping rectangles
7. Find the best rectangle of each the group (merging phase)

Rapid object detection (Viola Jones)

Optimized merging phase

Rectangles are used partitioned into a disjoint set data structure. On this work it was replaced by an alternative called Minimum Neighbor Area Grouping.

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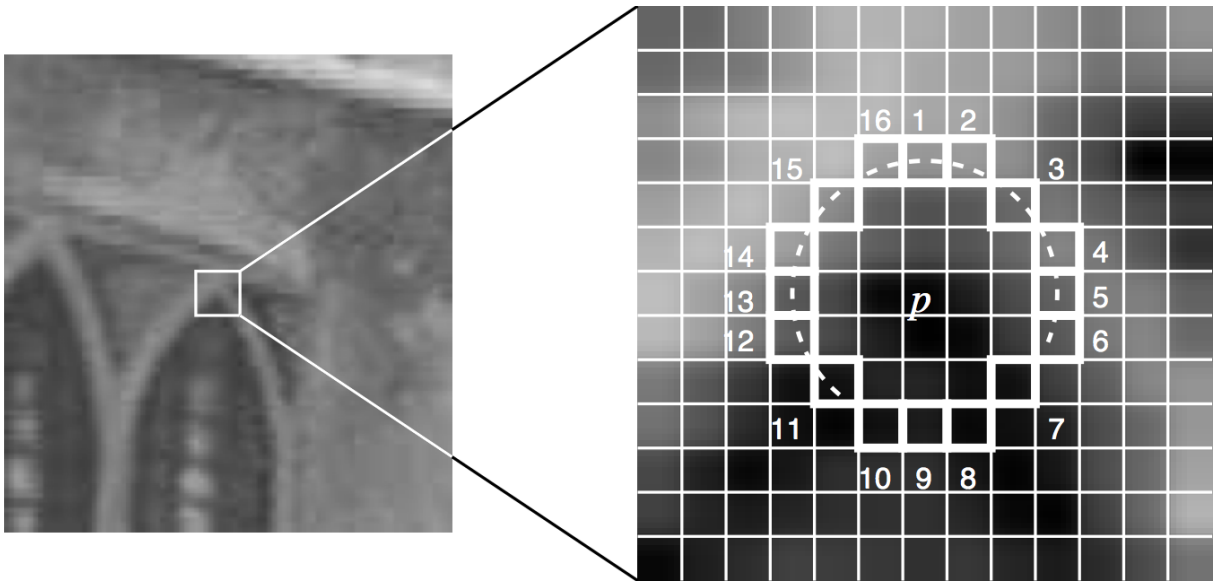
Minimum Neighbor Area Grouping

Simple loop trough the possible rectangles comparing the current rectangle with all other not yet compared. If their area overlaps by $\eta = 0.5$ the smallest rectangle of the set is selected.

Feature detector (FAST)



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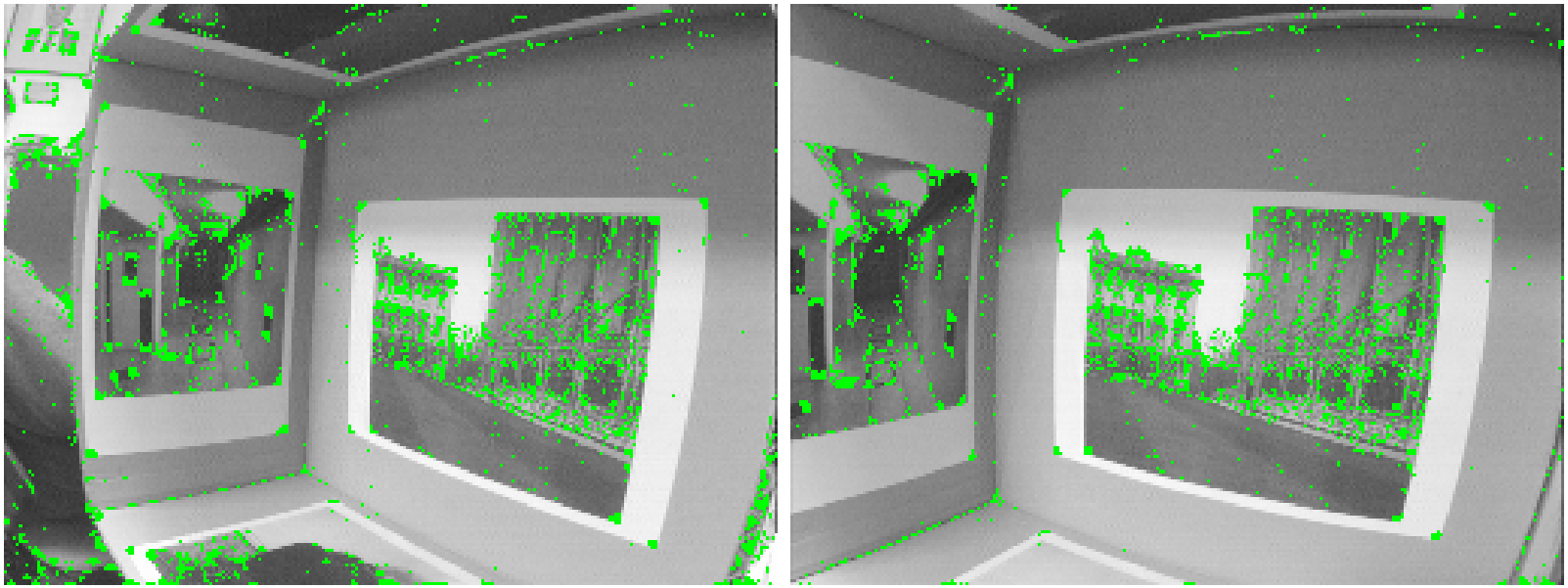
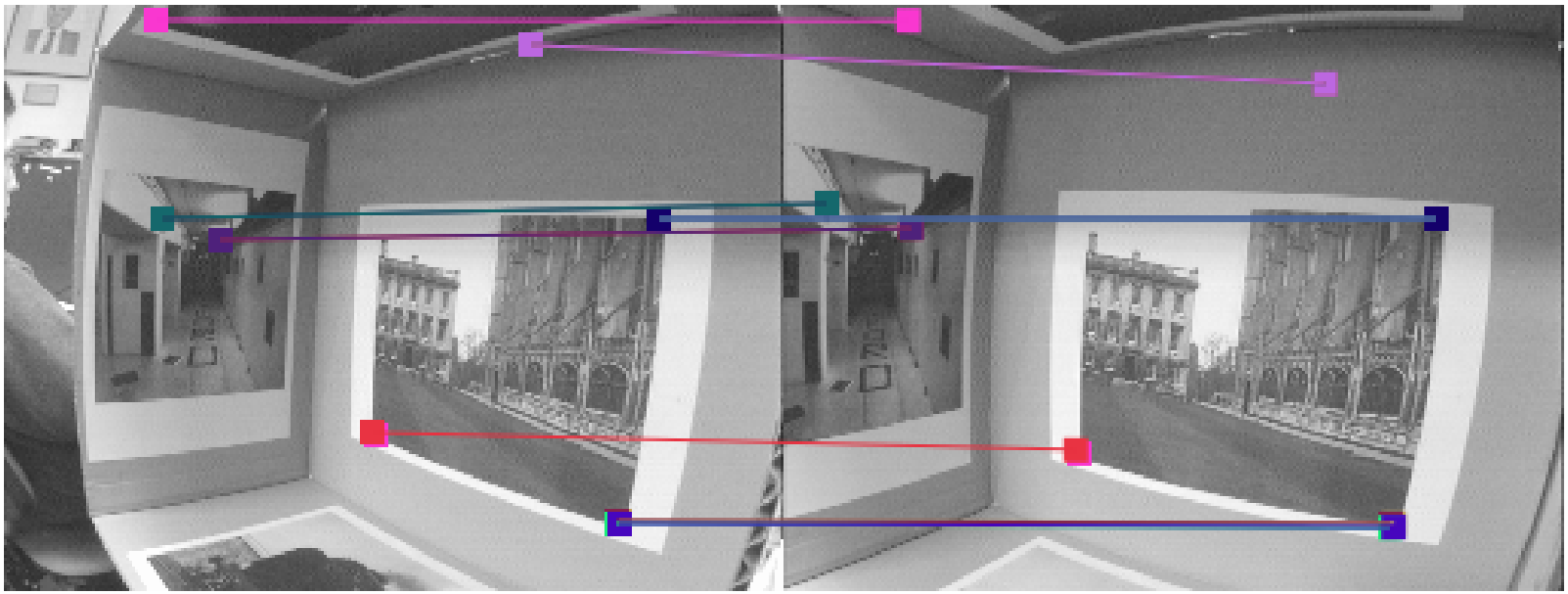


Feature extractor (BRIEF)



Feature extractor (BRIEF)

To generate the binary strings it is defined the test τ on patch $\mathbf{p}$ of size $\mathbf{S} \times \mathbf{S}$ as:

$$\tau(\mathbf{p}; x, y) := \begin{cases} 1 & \text{if} \quad \mathbf{p(x)} < \mathbf{p(y)}, \\ 0 & \text{otherwise} \end{cases}$$

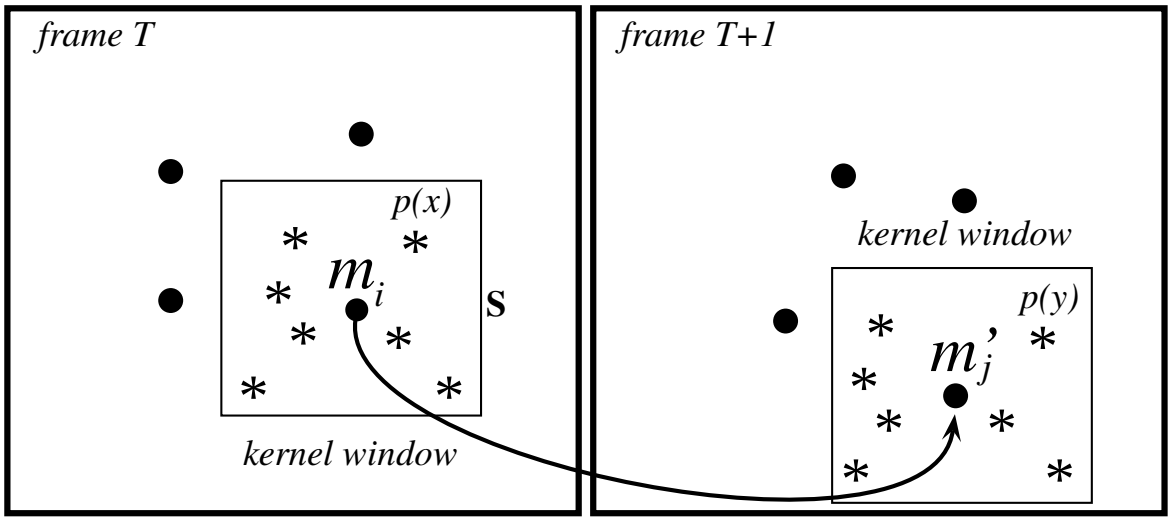
Feature extractor (BRIEF)

The n_d-dimensional bit-string is our BRIEF descriptor for each keypoint:

$$f_{n_d}(\mathbf{p}) := \sum_{1 \leq i \leq n_d} 2^{i-1} \tau(\mathbf{p}; x, y).$$

In this work $n_d = 128$ was used. The number of bytes required to store the descriptor can be calculated by $k = n_d/8$.

Feature extractor (BRIEF)



Feature extractor (BRIEF)

The weighted Hamming distance is computed by:

$$WHam(x, y) = \sum_{i=1}^{n} w_i(b_i(x) \otimes b_i(y))$$

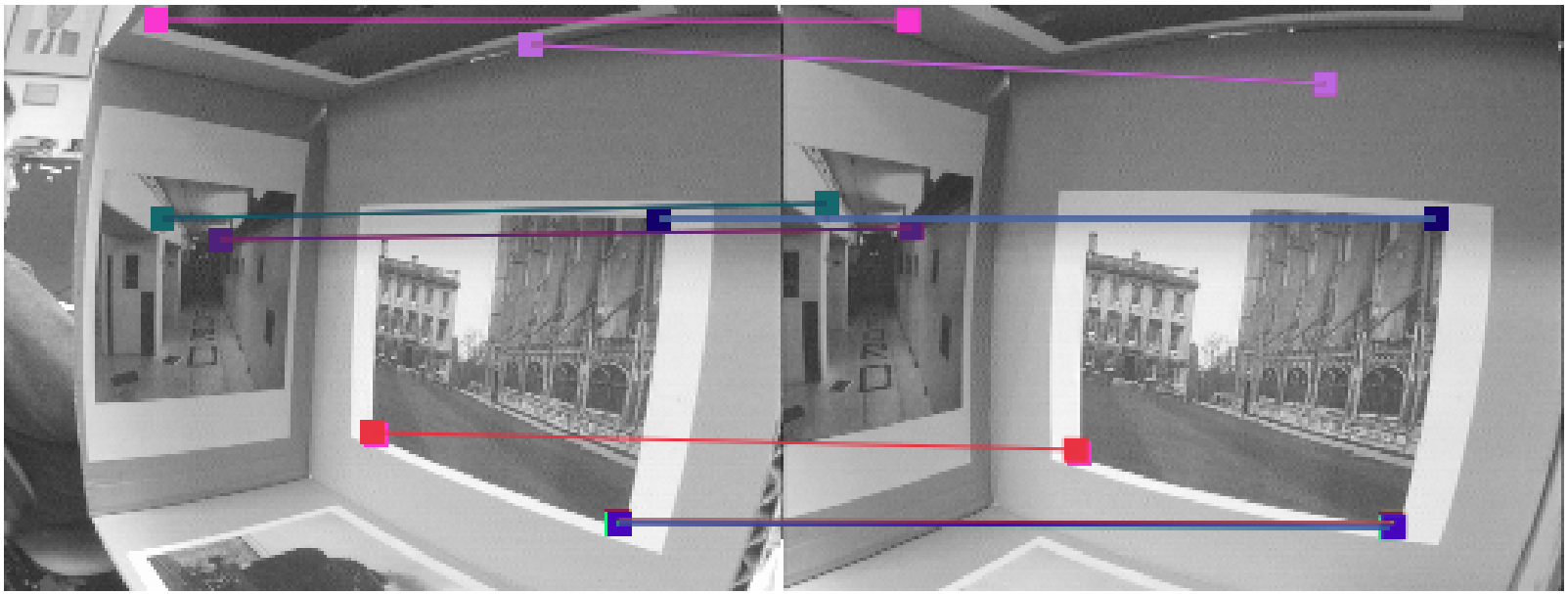
$$b_1 = 0000000001...$$

$$b_2 = 0000000011...$$

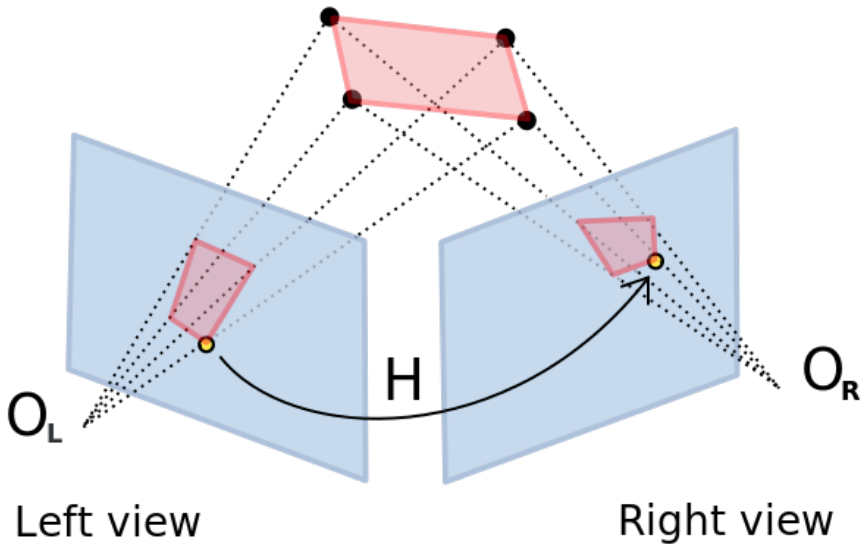
$$b_1 \otimes b_2 = 0000000010...$$

$$WHam = 1$$

Feature extractor (BRIEF)



Homography estimation



Random sample consensus (RANSAC)

RANSAC (Random Sample Consensus) is an iterative method to estimate parameters of a mathematical model from a set of observed data which contains outliers. It is the most commonly used robust estimation method for homographies.

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Evaluation methodology

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2. Performance

Frames per second (FPS) metric. All tests were executed on Google Chrome browser version 28.0.1500.71, Mac OS X 10.8.3, 2.6 GHz Intel Core i7 16 GB 1600 MHz RAM.

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3. Partial occlusion robustness

Examples of how each technique behaves under partial occlusion.

Evaluation methodology

README.md

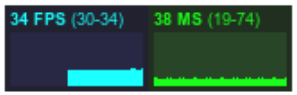
stats.js

JavaScript Performance Monitor

This class provides a simple info box that will help you monitor your code performance.

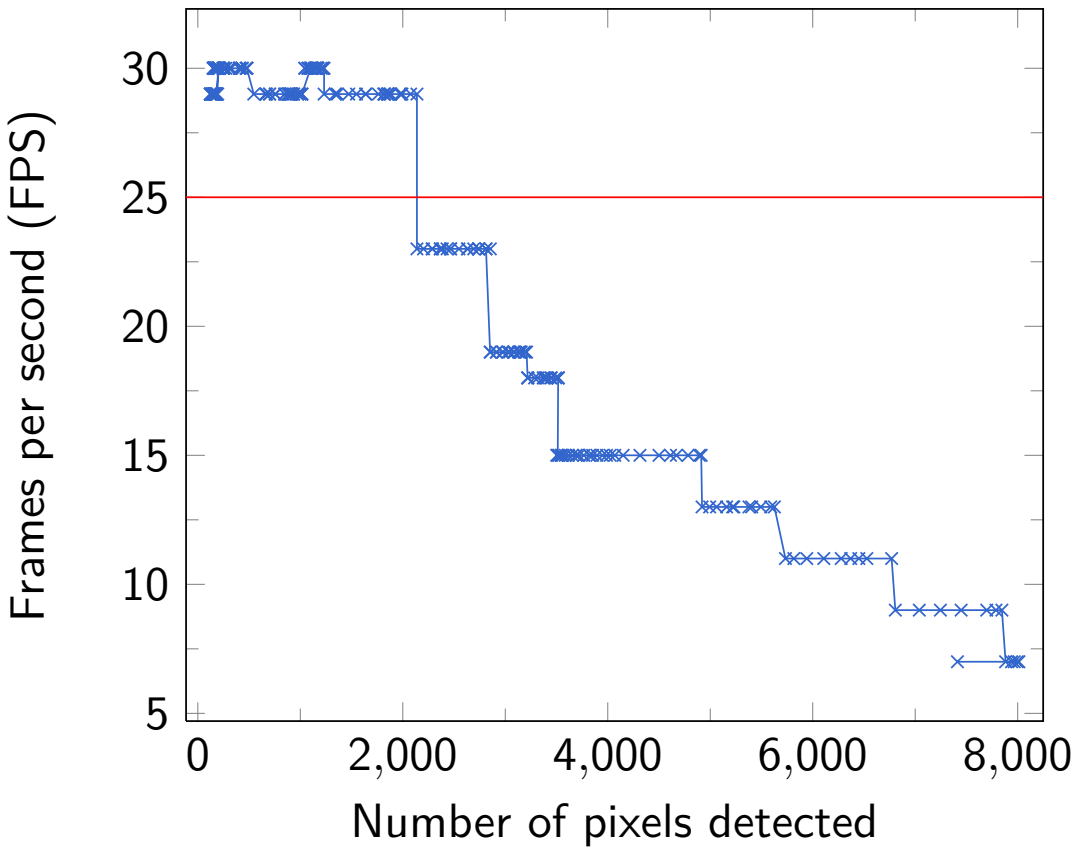
- **FPS** Frames rendered in the last second. The higher the number the better.
- **MS** Milliseconds needed to render a frame. The lower the number the better.

Screenshots

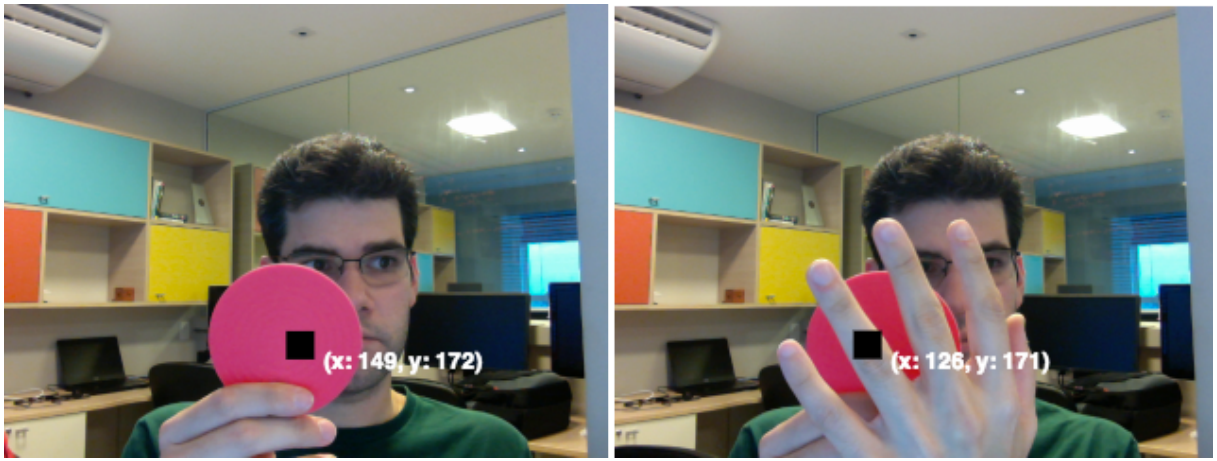


Examples

Performance



Oclusion robustness



Examples

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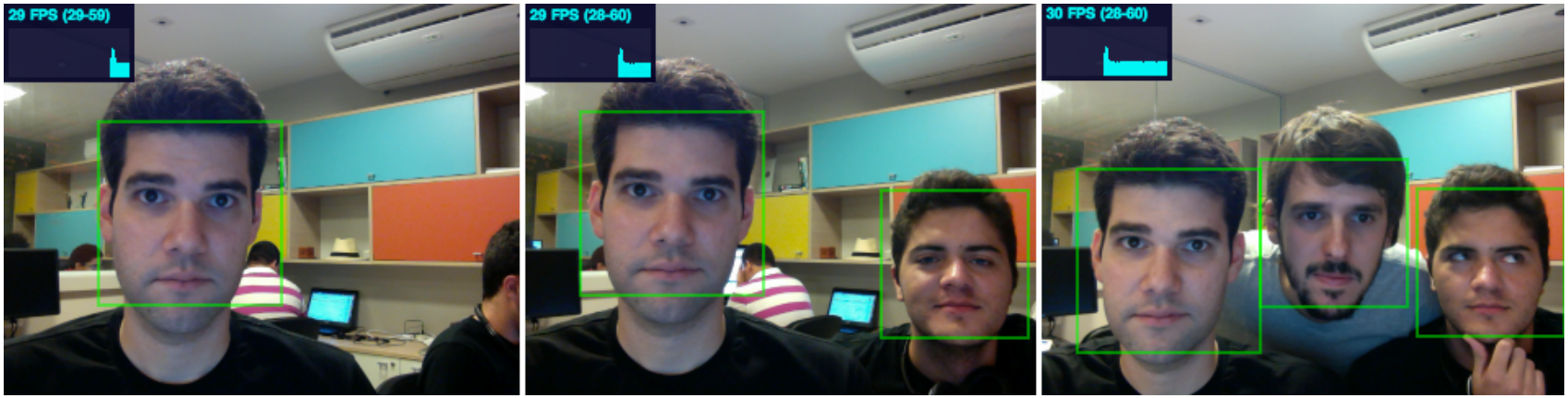
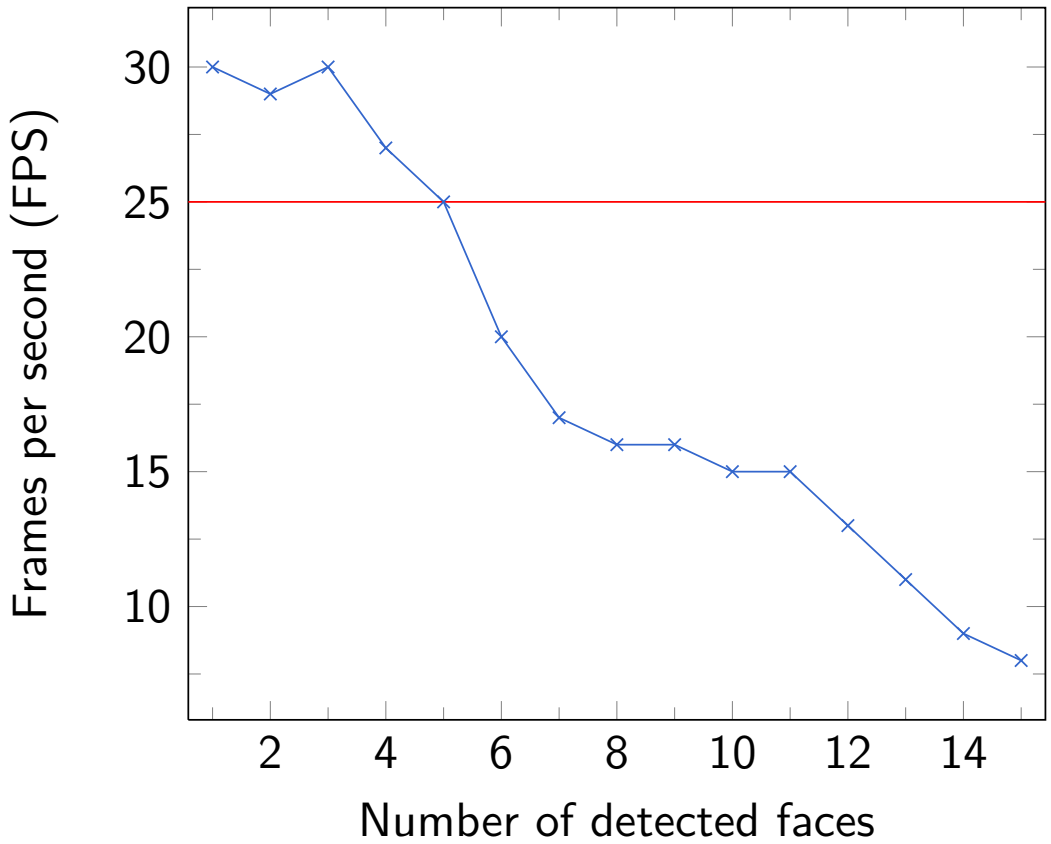
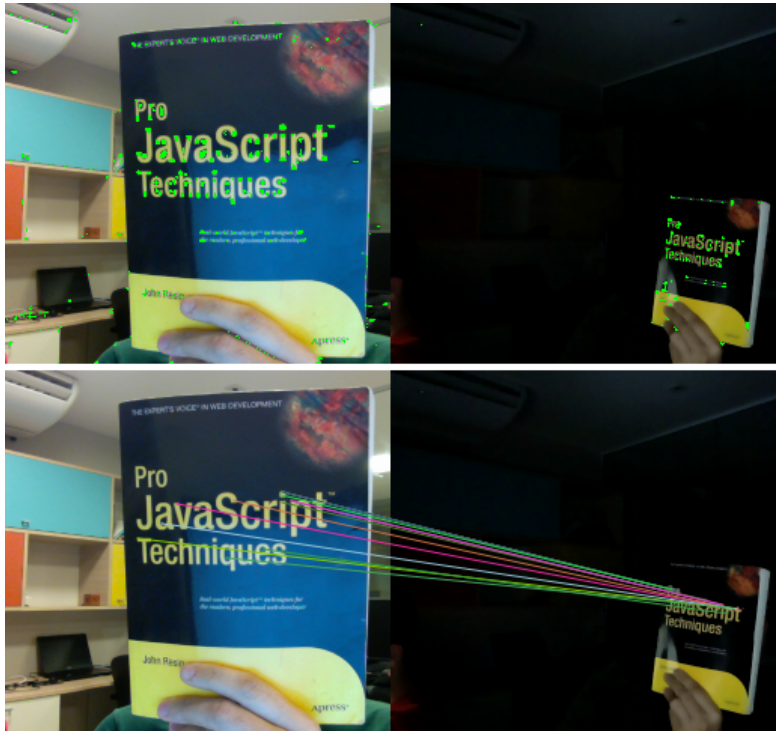


Performance



Oclusion robustness

Examples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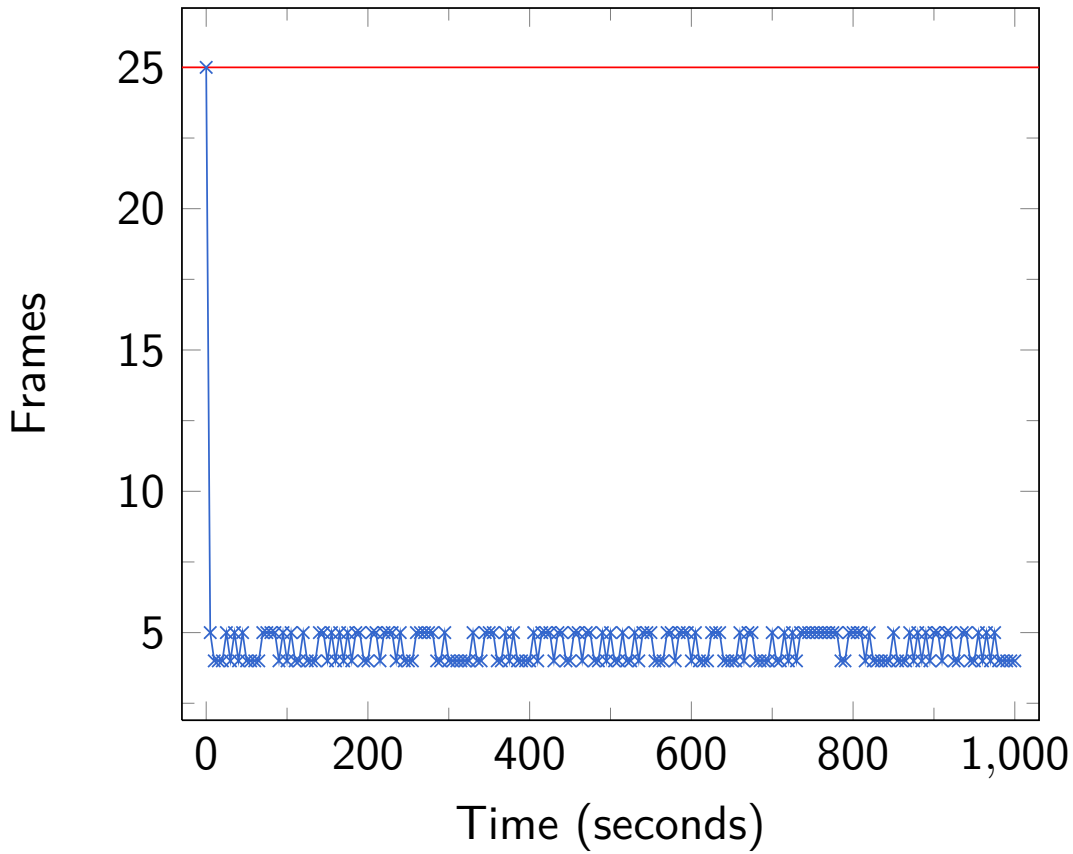

Oclusion robustness

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Benefits of a JavaScript tracking solution

	OSAKit	*tracking.js* + color	*tracking.js* + face
Avg frame rate	25 FPS	30 FPS	25 FPS
Avg file size	22 MB	8 KB	187 KB
Avg load time (256 Kbps)	11 min	0.25 seconds	5 seconds

Contributions

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- Academic material about web browser concepts

Future work

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- Image processing layer capable of transformations and filters

Bonus - Website

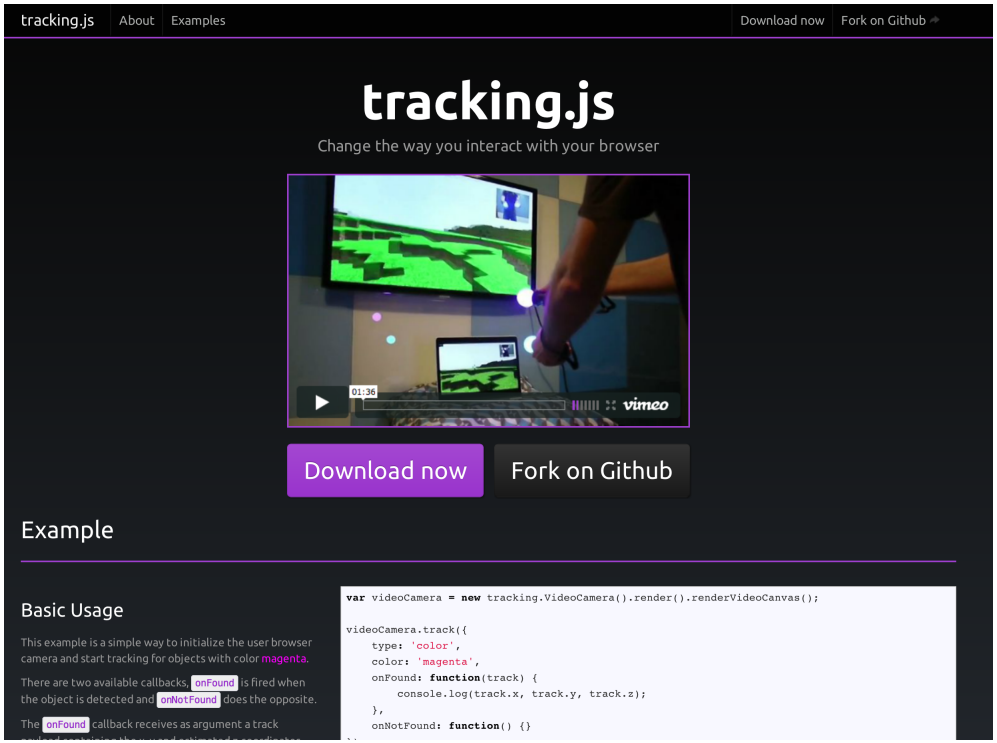
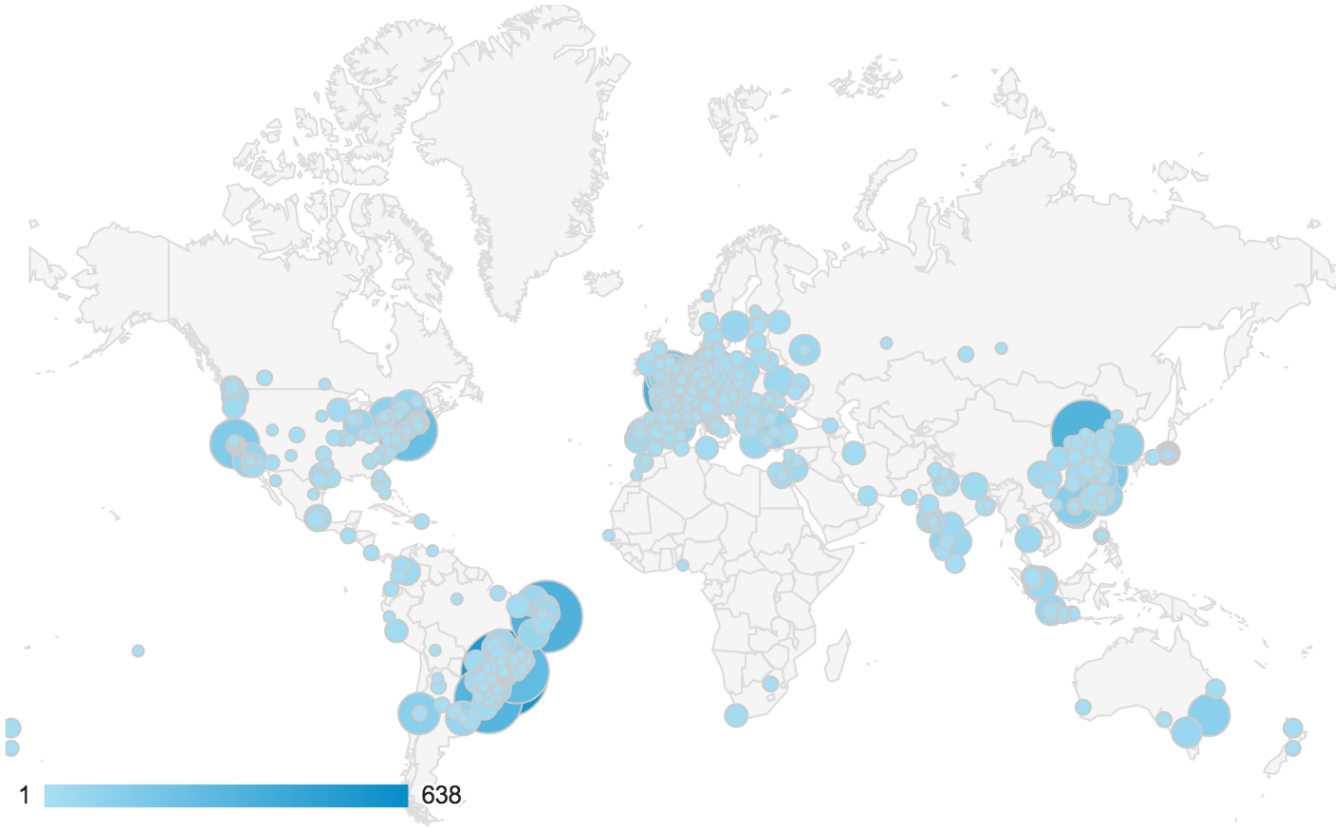


Figure : http://trackingjs.com

Bonus - Repercussion



Bonus - Repercussion

David Herman
@littlecalculist
Following

Spontaneous applause for Eduardo Lundgren's incredible demos of trackingjs.com #braziljs

Lisa Larson-Kelley
@lisamarienyc
Following

A library I wish I had back in the day with Flash -- #javascript #webcam gestures, tracking tracking.js buff.ly/1cmlNp2

HTML5 Weekly
@HTML5Weekly
Follow

Tracking.js: Webcam/Camera Based Interaction for Web Page Elements - trackingjs.com

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- Talk accepted on JS.everywhere - USA, 2013

Thank you!