An automatic video monitoring system for estimating driftwood discharge in large rivers

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Why should we monitor driftwood discharge automatically?

- Major need in wood budgeting and wood risk monitoring
  - Measure wood discharge (volume of wood passing through a section per unit time)
  - Different strategies
    - Reservoir / raft censing => only basin estimate
    - At a station (for river reaches – in between two stations)
      - Relatively sparse flux => need for video (to catch the flux)
      - Exhausting and time consuming to do it by visual analysis
      - Need to automatize the process

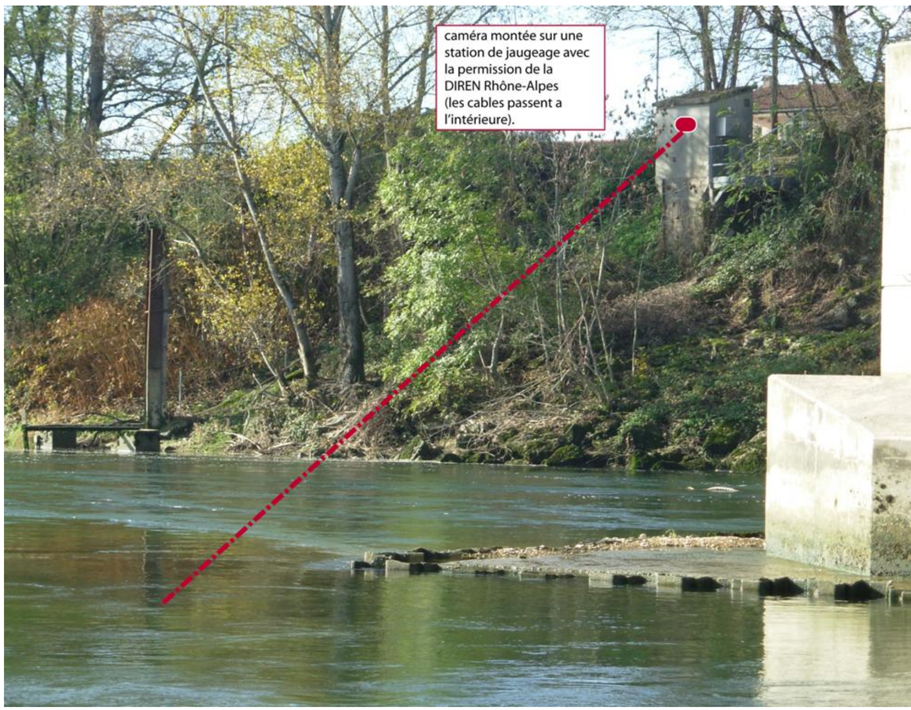
Our objectives

- Being able to detect automatically driftwood as best as we can:
  - From any size?
  - From any part in the section?
  - In any weather, water aspect and lighting conditions?

- Being able to extract data about wood blocks : size, speed, rotation speed, lateral position, form…

- If a complete automated system does not provide accurate enough results, it must facilitate manual annotation

- An example of a video that we are trying to analyse
  - At a gauge station on the Ain river

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Outline

- Method
  - Combining probability masks…
  - … and examining components movement…
  - … to extract and characterize wood blocks
- Evaluation and results
- Associated works and future developments

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Method

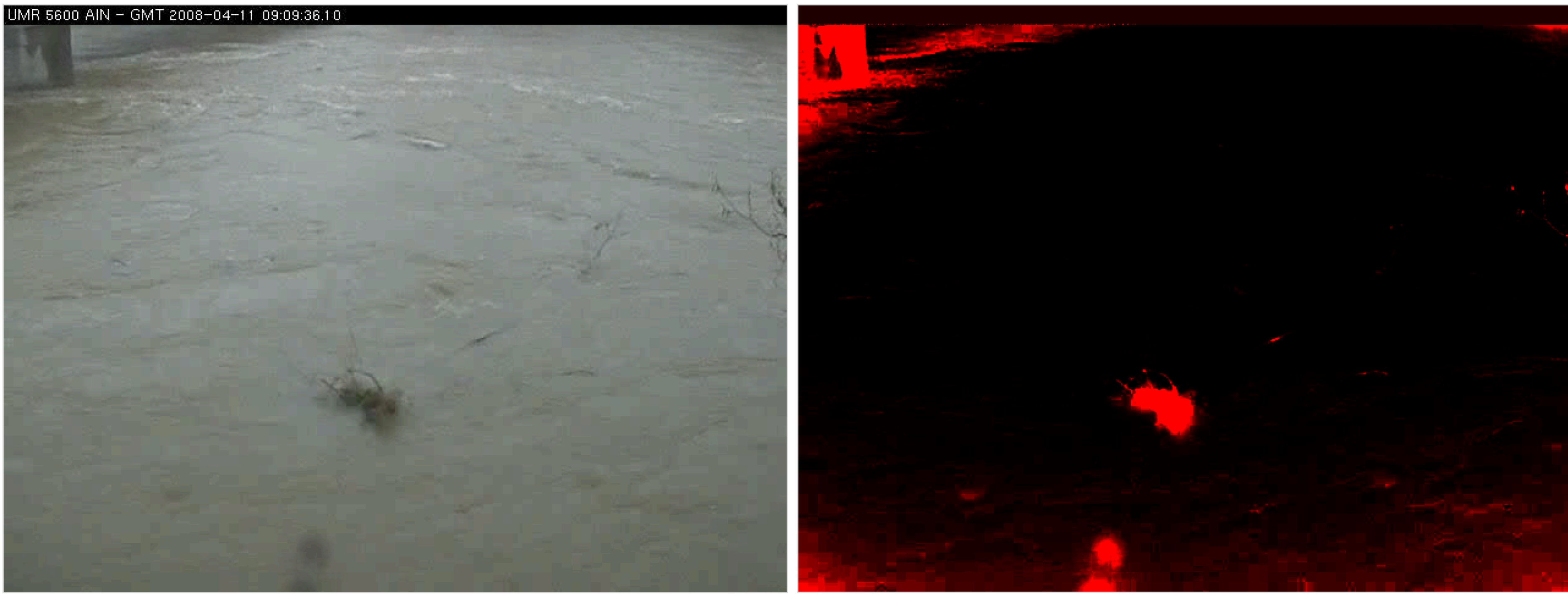
- Combining probability masks…
  - Pixels can belong to either background (most probably, water) or driftwood
  - Classifying pixels is equivalent to studying their probability of belonging to either class (driftwood or background)
  - In our works, this probability is a combination of **static** probability and **dynamic** probability, and makes use of **temporal and spatial informations**

Combining probability masks…

- **Static** probability mask :
  - For every pixel, we answer the following question :

    “Given the pixel’s colour and intensity, is it likely to belong to driftwood or background?”

  - We used mainly a Gaussian distribution model on pixel intensity in grayscale images (which means that we expect every driftwood occurrence to have the same intensity)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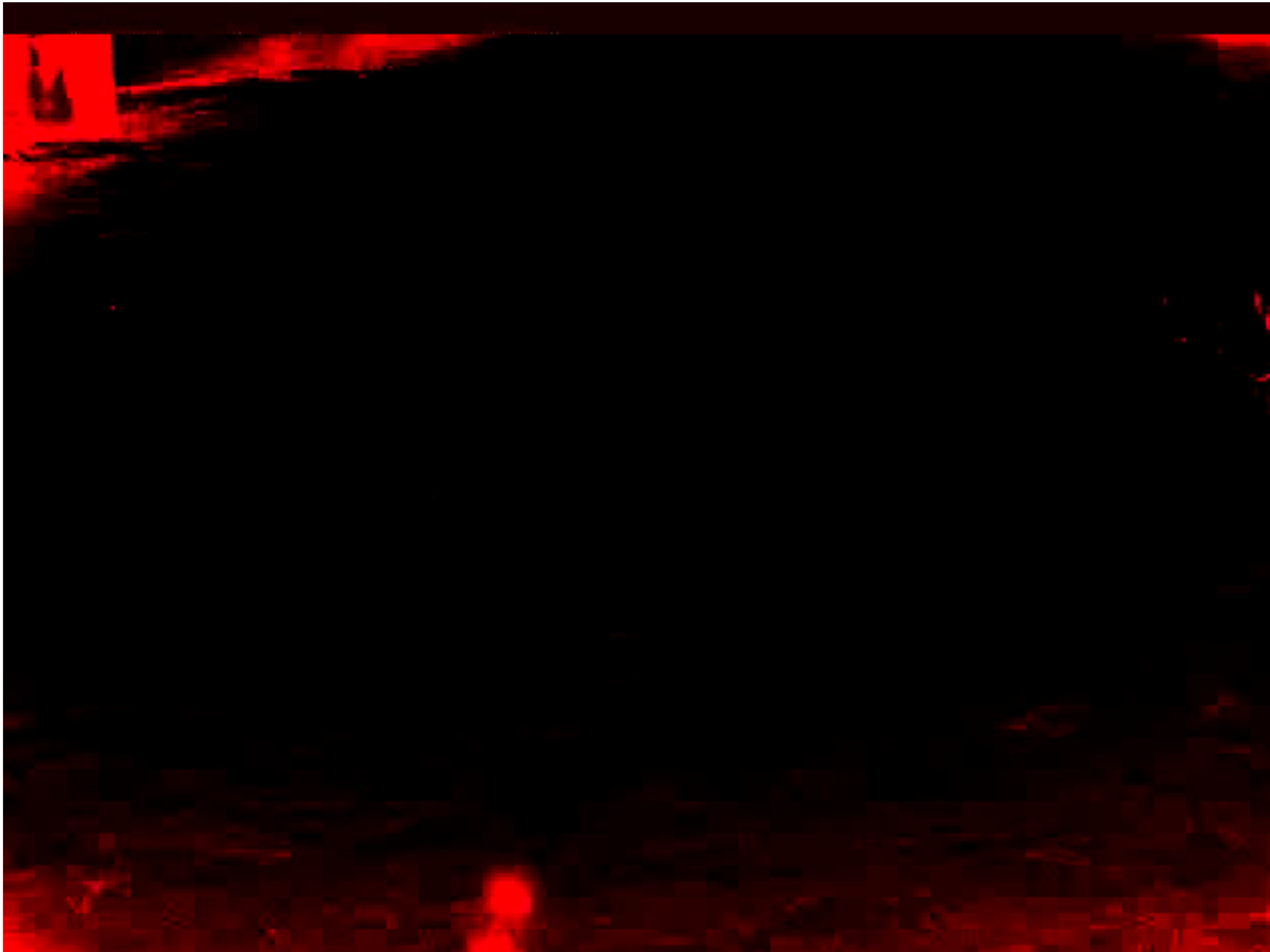

Combining probability masks…

- **Dynamic** probability mask :
  - For every pixel, we answer the following question :

    “Given the pixel’s past and current values, is it likely to belong to driftwood or background?”

  - We used a transfer function where pixels get excited when they become suddenly and significantly darker


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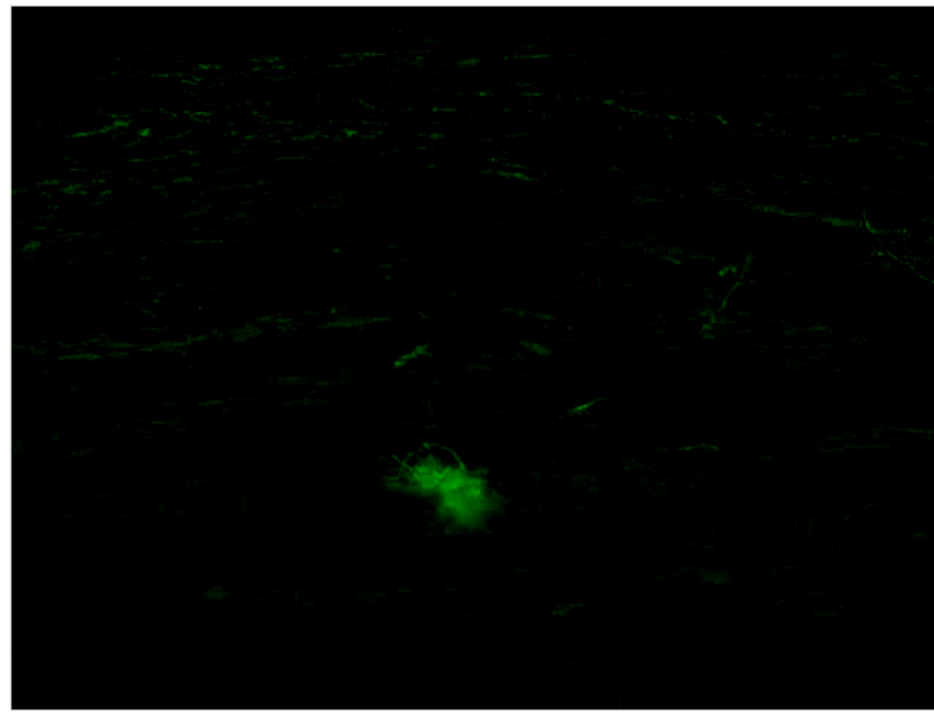

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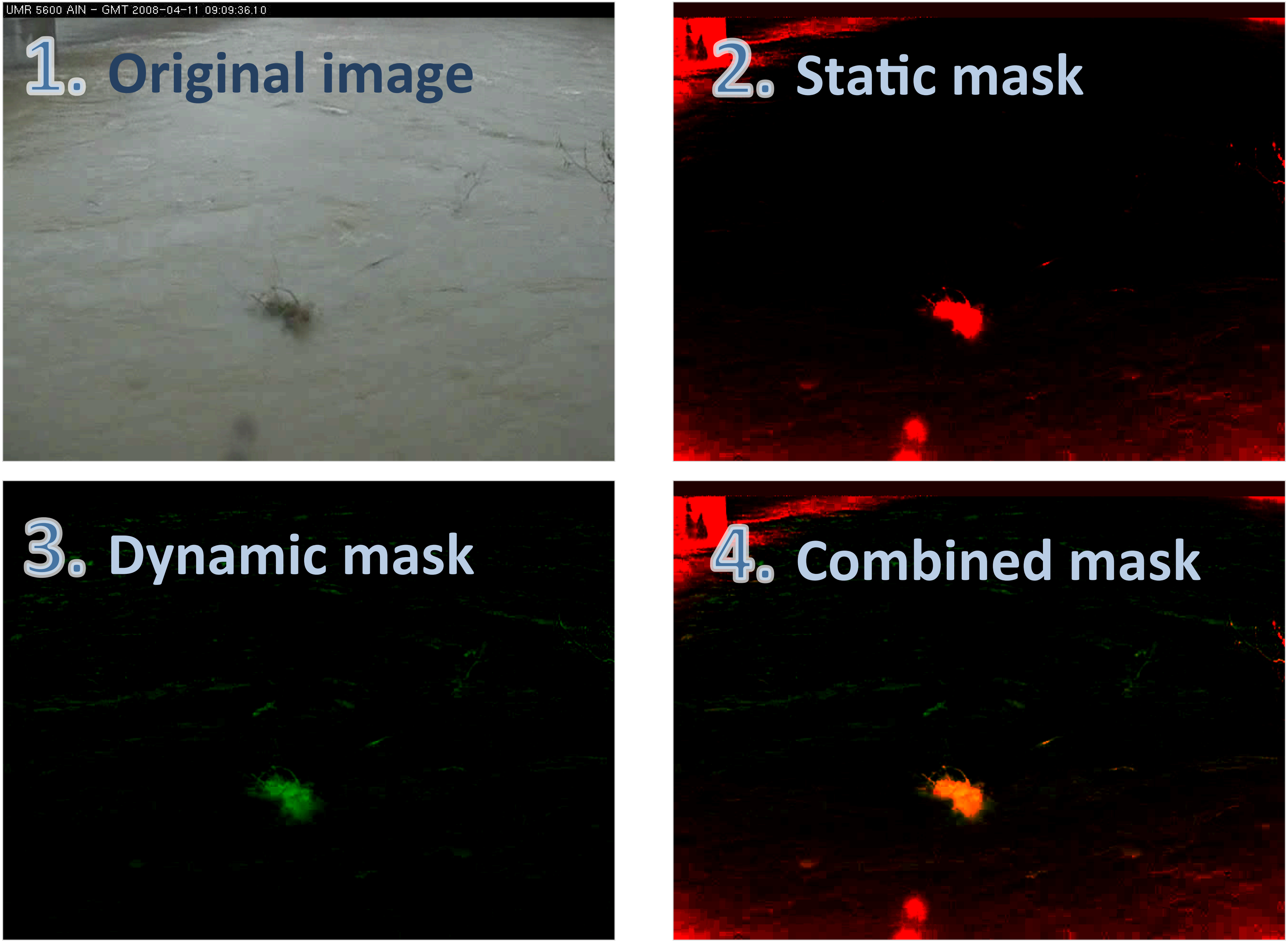
Combining probability masks…

- We make the approximation that both probabilities are independent from each other
- Combining both probability masks is similar to multiplying each mask value, pixel per pixel
- Combined images are filled with few high intensity values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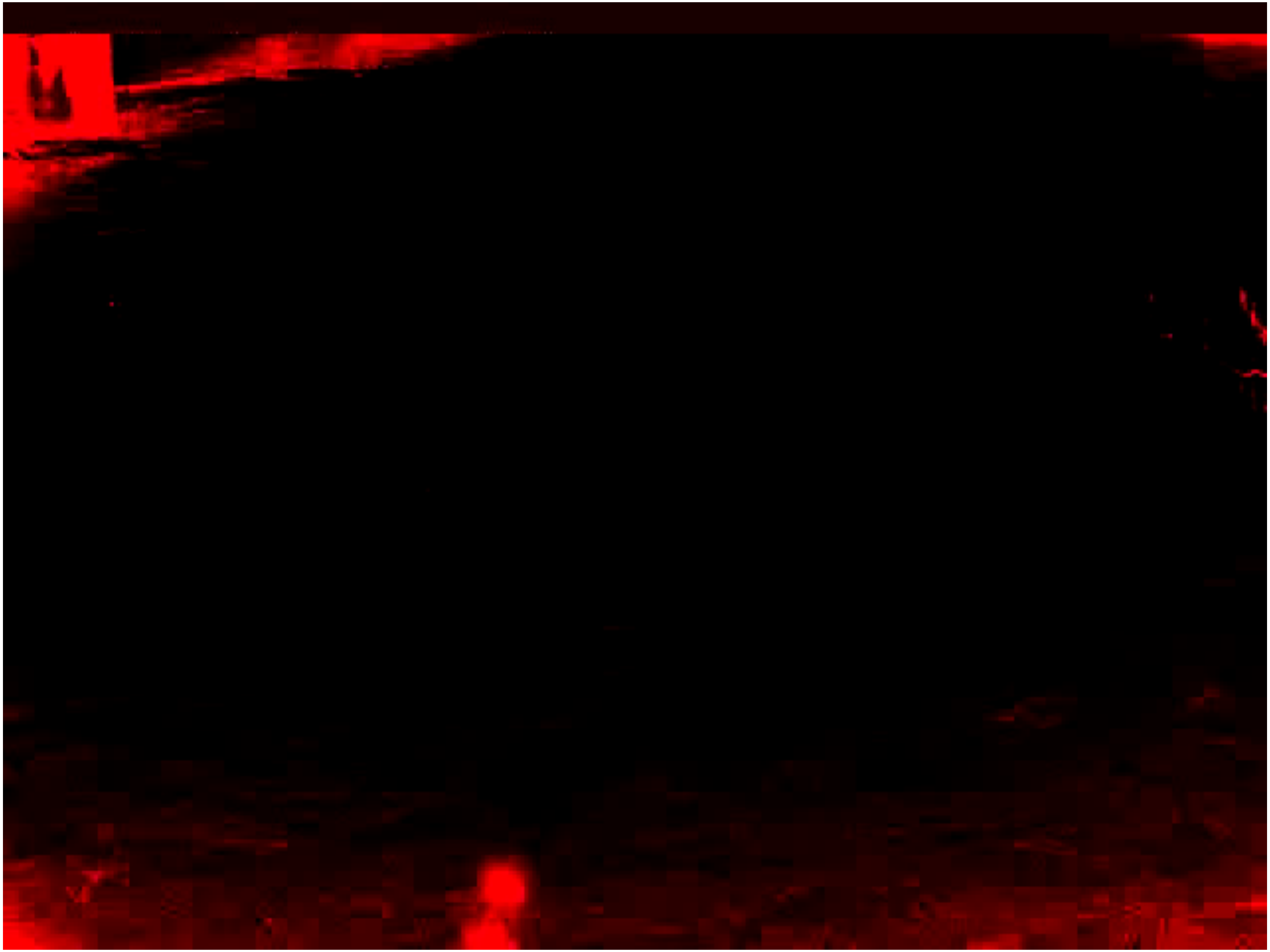
1. Original image
2. Static mask
3. Dynamic mask
4. Combined mask



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… and examining components movements

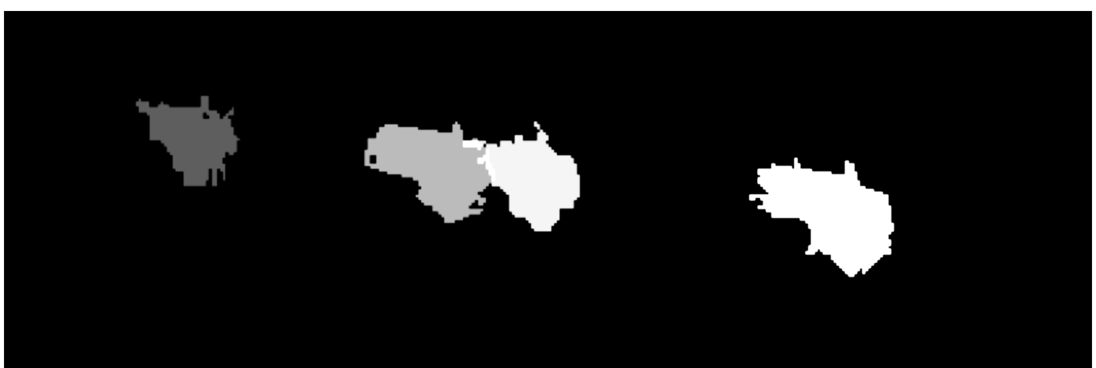
- We group pixels of high value into blobs (called connex components).
- We remove the smallest components due to background noise

- Now, we are looking forward to classifying connex components as driftwood or noise

… and examining components movements

- We match components from frame to frame, expecting certain movement quantities and directions

- Once we observe a sufficient number of matches, and a smooth trajectory, we assume that we are observing a wood block



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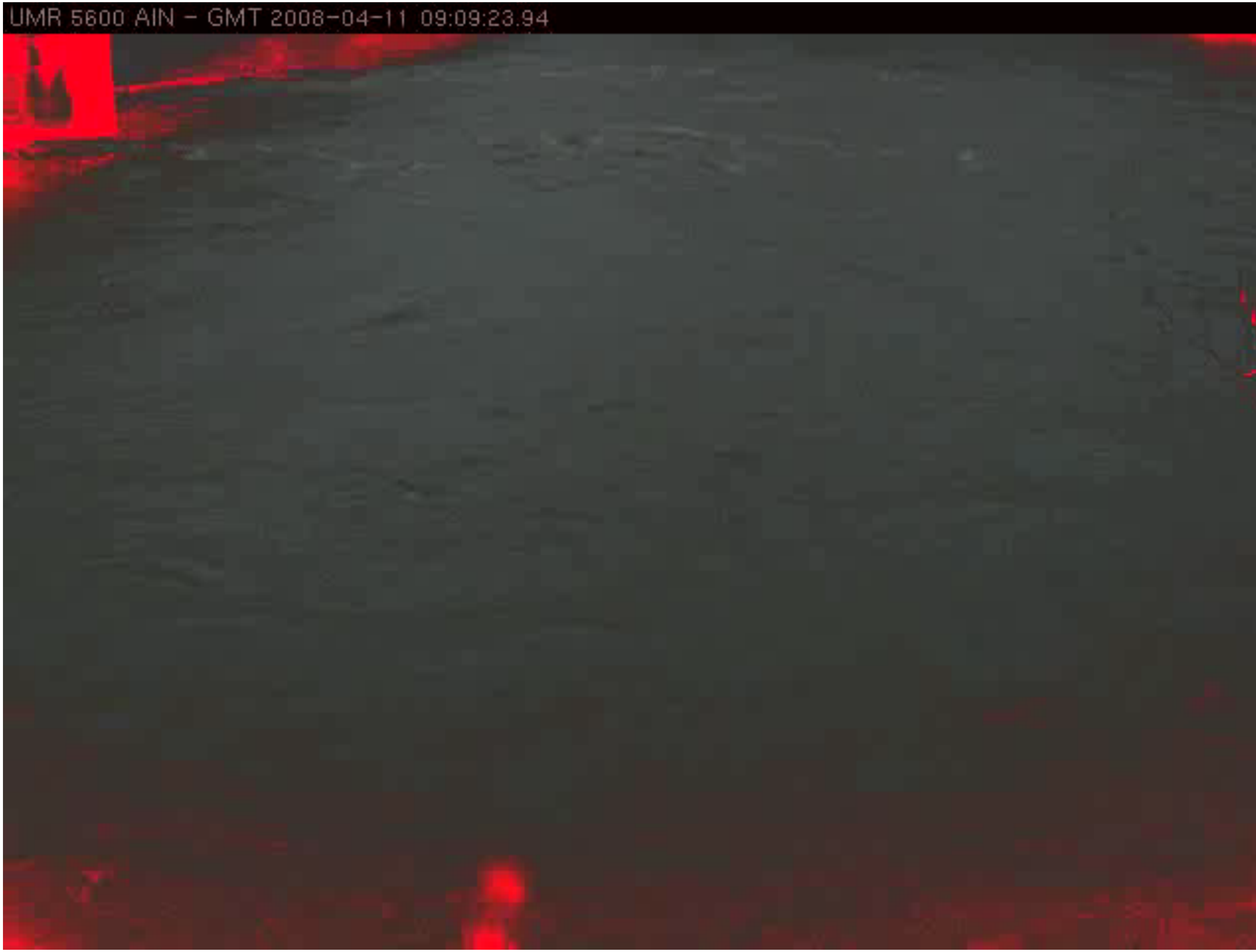
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… to extract and characterize wood blocks

- When a wood block is extracted, it consists in a set of views along the image

- We build a skeleton for each view. It allows us to find boundaries and extract the radius (in pixels) at each point

- Finally, the image is ortho-rectified thanks to coordinates acquired relative to the camera. Pixels are translated to metrics data.

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Evaluation and results

- The presented system is fully automatic
- We need to compare it to manually annotated data in order to know how accurate our algorithm and its settings are
- During 2007 and 2008, 3 floods were annotated by an operator (MacVicar and Piégay, 2012)
- We matched human annotations with our software output

Evaluation and results

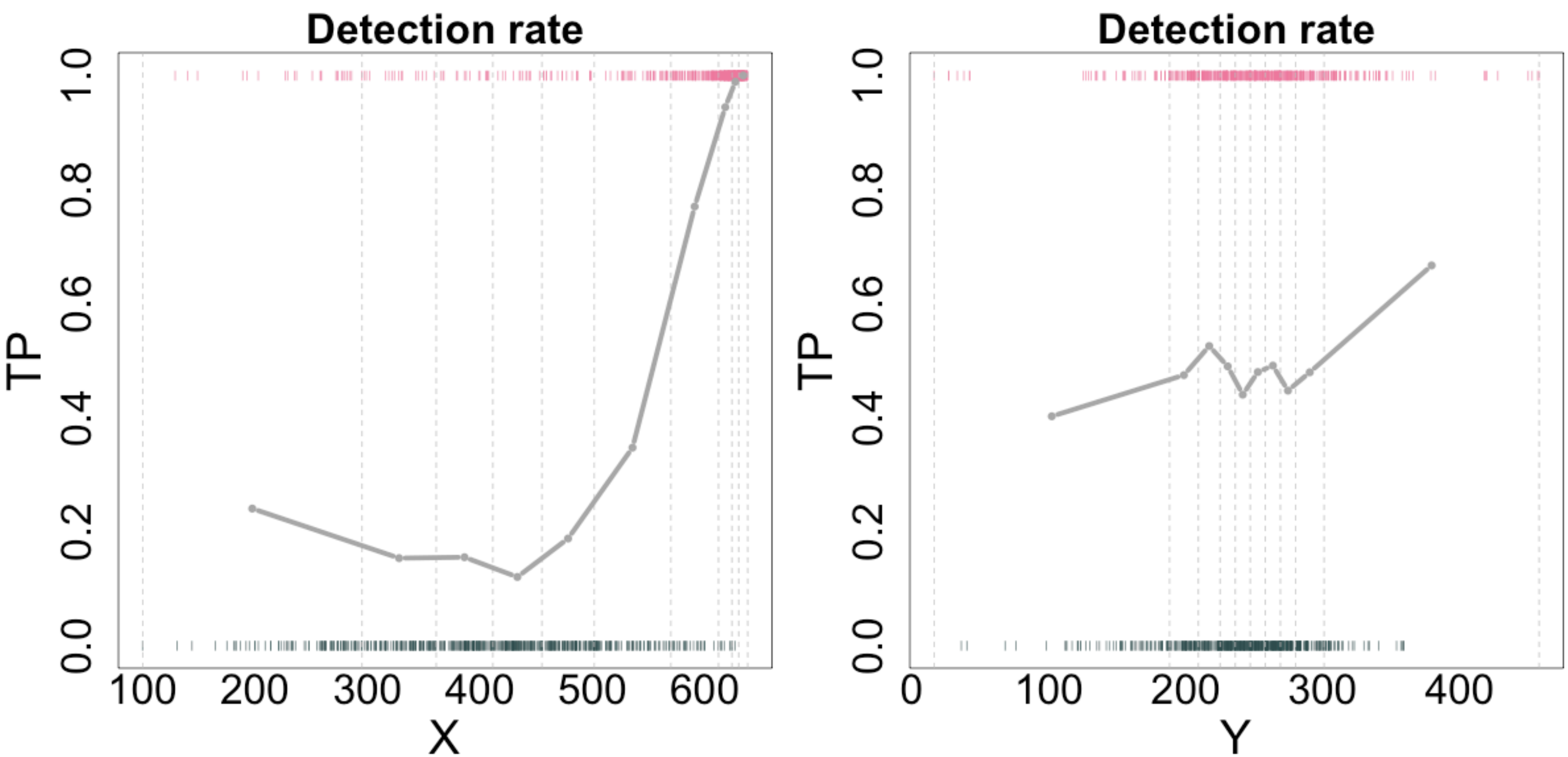
- For each block, 3 outputs are possible :

	Detected	Annotated
True Positive (TP)	YES	YES
False Positive (FP)	YES	NO
False Negative (FN)	NO	YES

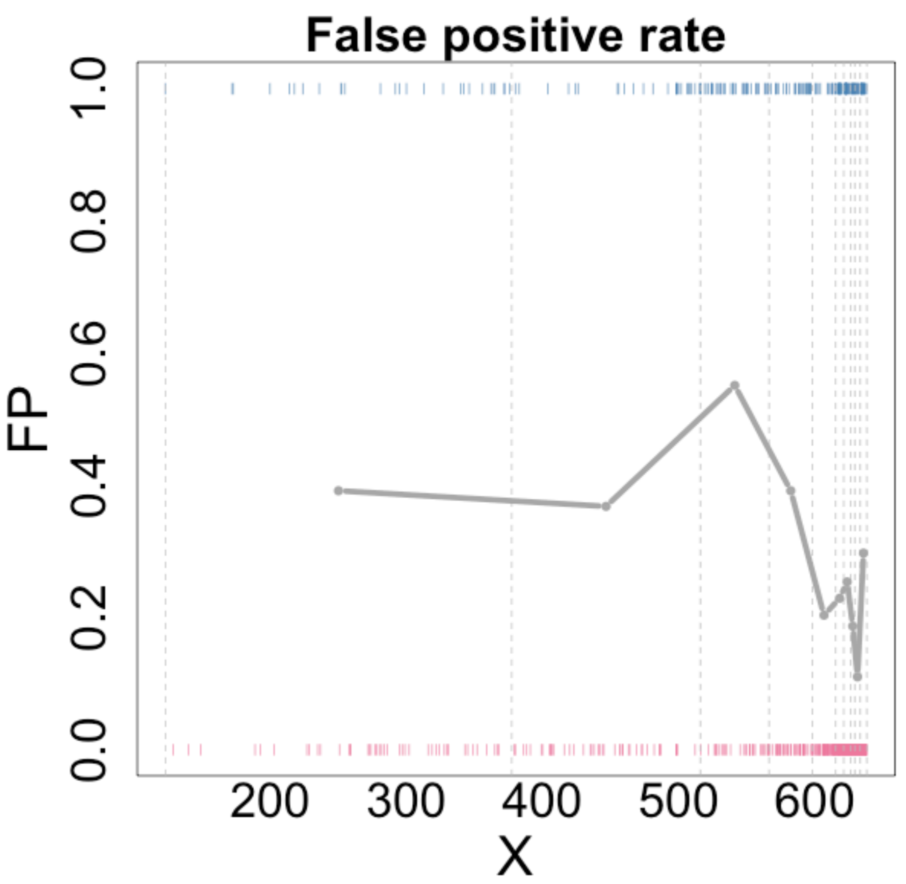
- Detection rate (or TP rate) is the number of TP cases over the whole population (TP+FP+FN)

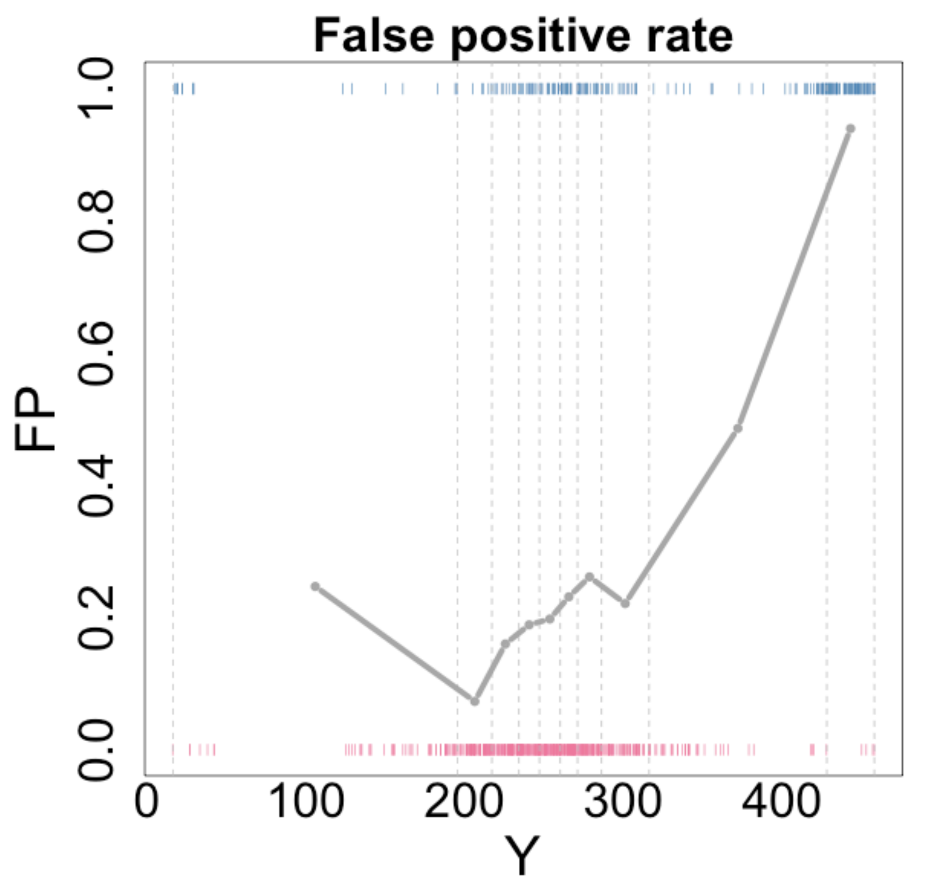
- We want to know how performances are affected by:
  - wood block position in the image?
  - wood block size?
- We kept the best view (that is, when the size is bigger) as an indicator to where the detection occurred. Most of the time, it is coherent with where the tracking actually took place.

- TP rate in function of the position (in pixels) within the image
  - X increases from upstream to downstream
  - Y increases from the front end to the rear end

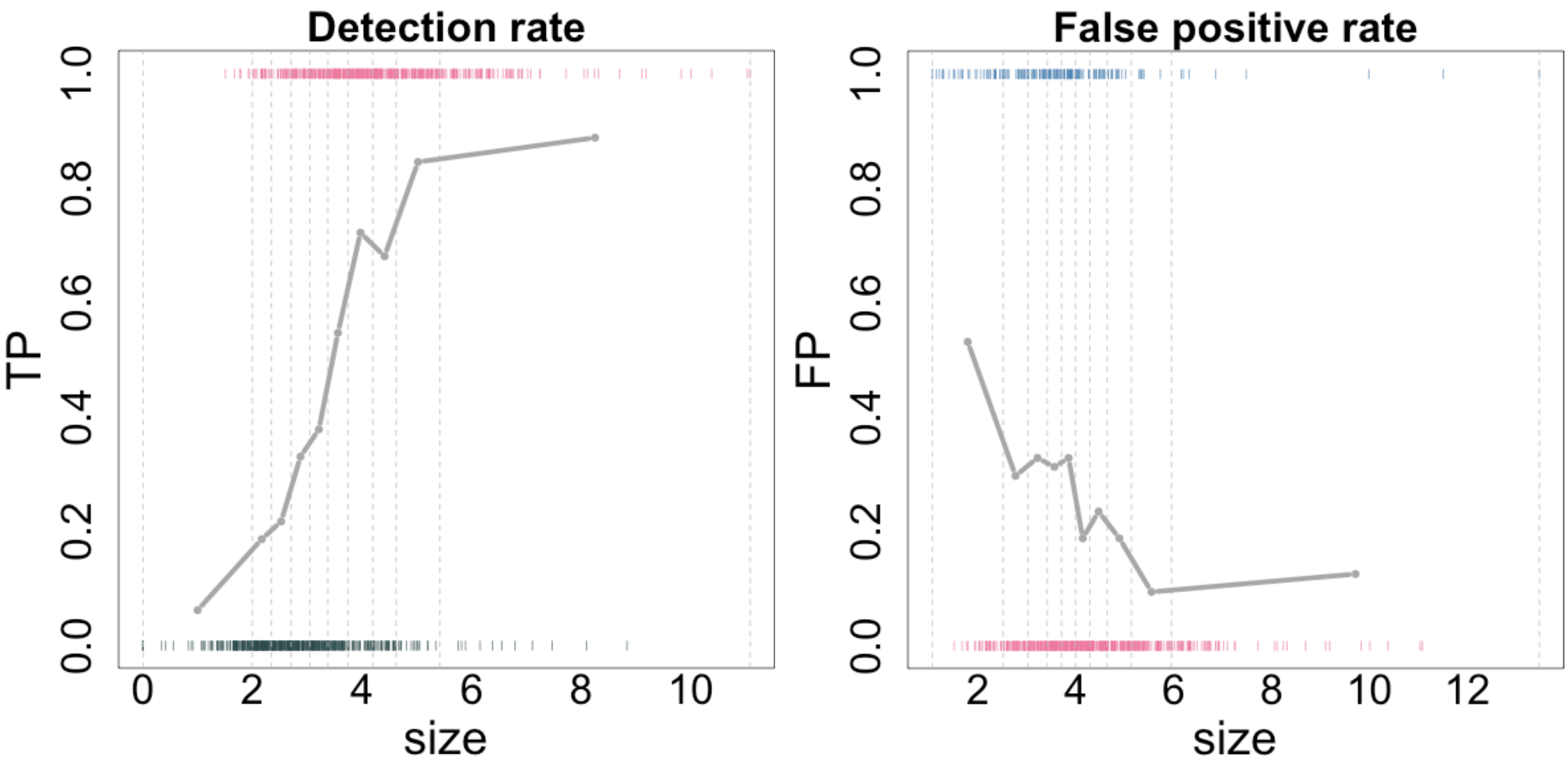


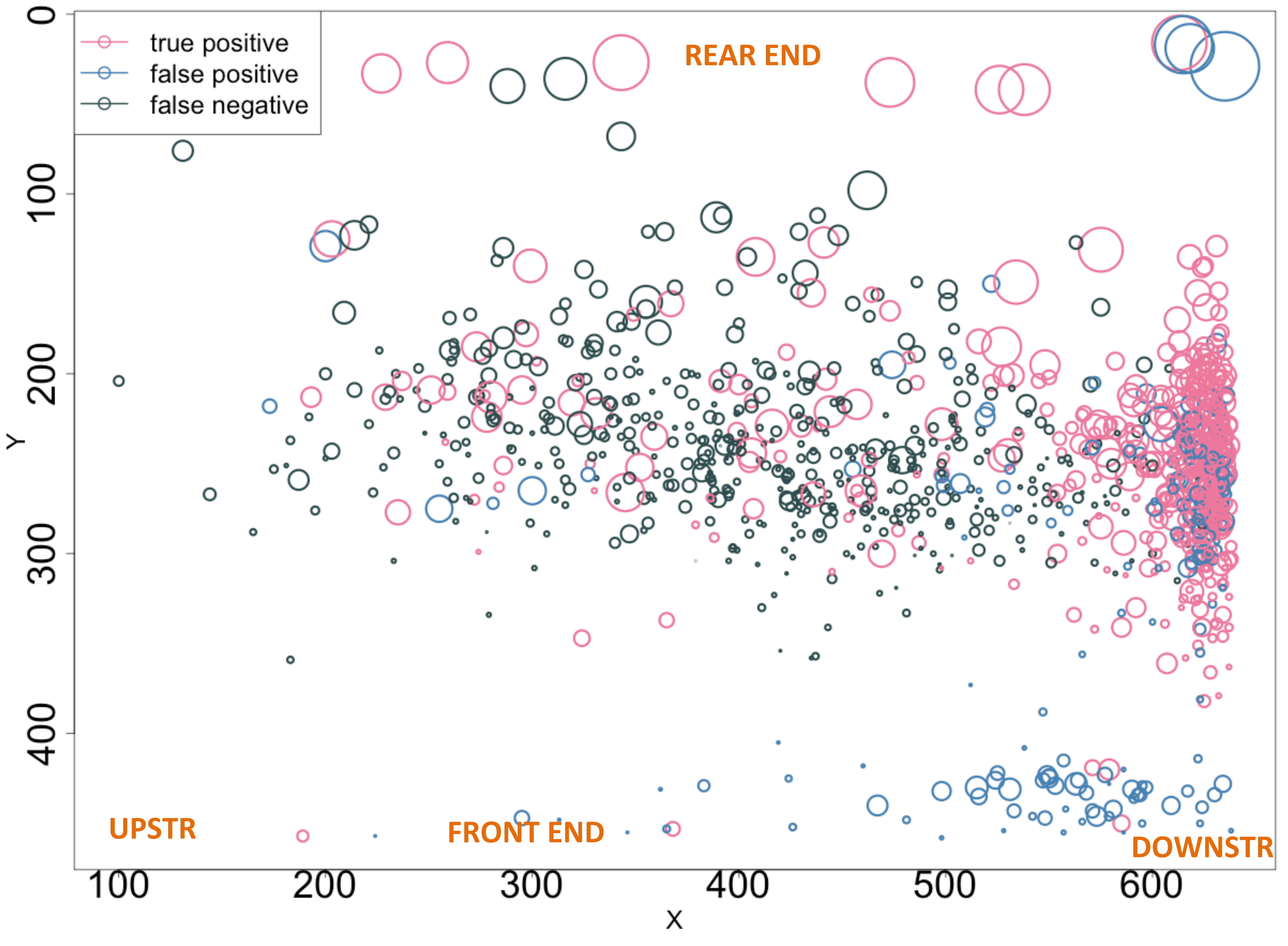
- FP rate in function of the position (in pixels) within the image
  - X increases from upstream to downstream
  - Y increases from the front end to the rear end





- FP and FN rates in function of the size of blocks
  - Size is an indicator based on the maximal length and the maximal radius.




true positive
false positive
false negative
REAR END
UPSTR
FRONT END
DOWNSTR
Y
X
0
100
200
300
400
100
200
300
400
500
600

What does the evaluation show?

- As expected, bigger blocks are better detected, although we can miss big blocks at the rear end of the image. Reliability is greater than 80% when size > 15 Liters.
- There is room for improvement in this experiment : we can see patterns, in particular in FPs, and we can probably filter out detections so that results are improved
- Turbulent structures caused by the bridge pile probably impact our performances

  => feedback to improve camera location

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Associated works and future developments

- We developed an User Interface to annotate videos.
  - Automatic video characterization can be used as a basis for annotations
- We want to base our parameters and algorithms more on learnt data (annotation-driven). We are currently investigating means of improving the performances in general, including the robustness to partly submerged blocks

Associated works and future developments

- Tests with other setups:
  - We are currently testing the software with videos provided by Maxime Boivin.
    - More fps and resolution impact the performances.
    - Those videos embed ice as well as wood. First results are encouraging.

Thank You for Your attention

& Questions?