



## European Ph.D. defense

Communauté  
d'Agglomération de  
**La Rochelle**

# Segmentation and indexation of complex objects in comic book images

Christophe Rigaud  
December 11<sup>th</sup>, 2014

Co-supervised by:

Jean-Christophe Burie<sup>1</sup>  
Dimosthenis Karatzas<sup>2</sup>  
Jean-Marc Ogier<sup>1</sup>

# Comic books

## Introduction

*“a visual medium used to express ideas via images, often combined with text or visual information”*

Wikipédia, 2014

*“One of the most popular and familiar forms of graphic content”*

Hiroaki Tobita, Sony CSL Interaction Laboratory, 2014

# Comic books

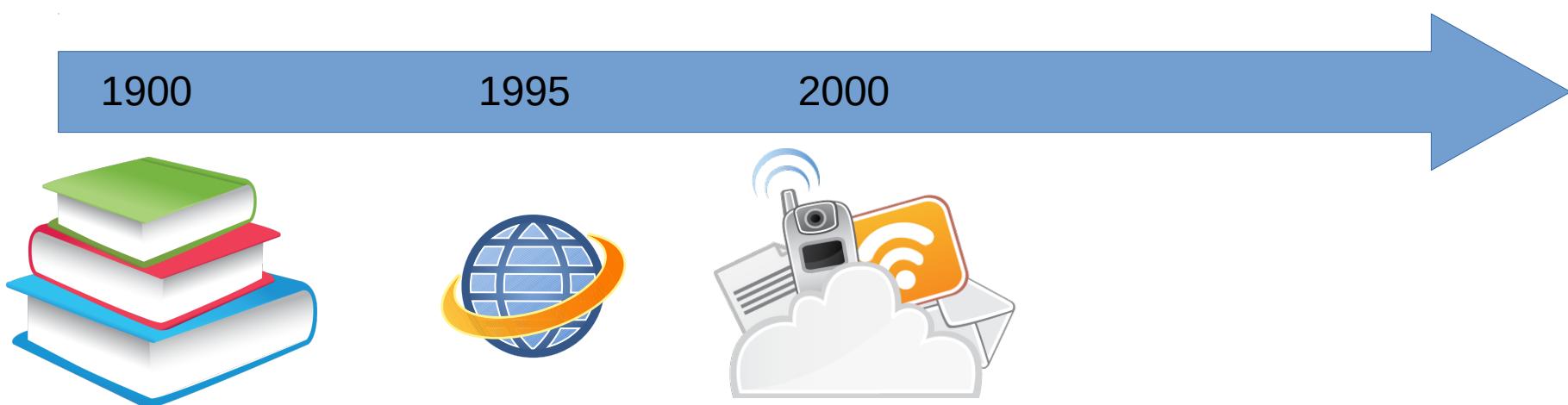
## Introduction

*“a visual medium used to express ideas via images, often combined with text or visual information”*

Wikipédia, 2014

*“One of the most popular and familiar forms of graphic content”*

Hiroaki Tobita, Sony CSL Interaction Laboratory, 2014



# Comic books

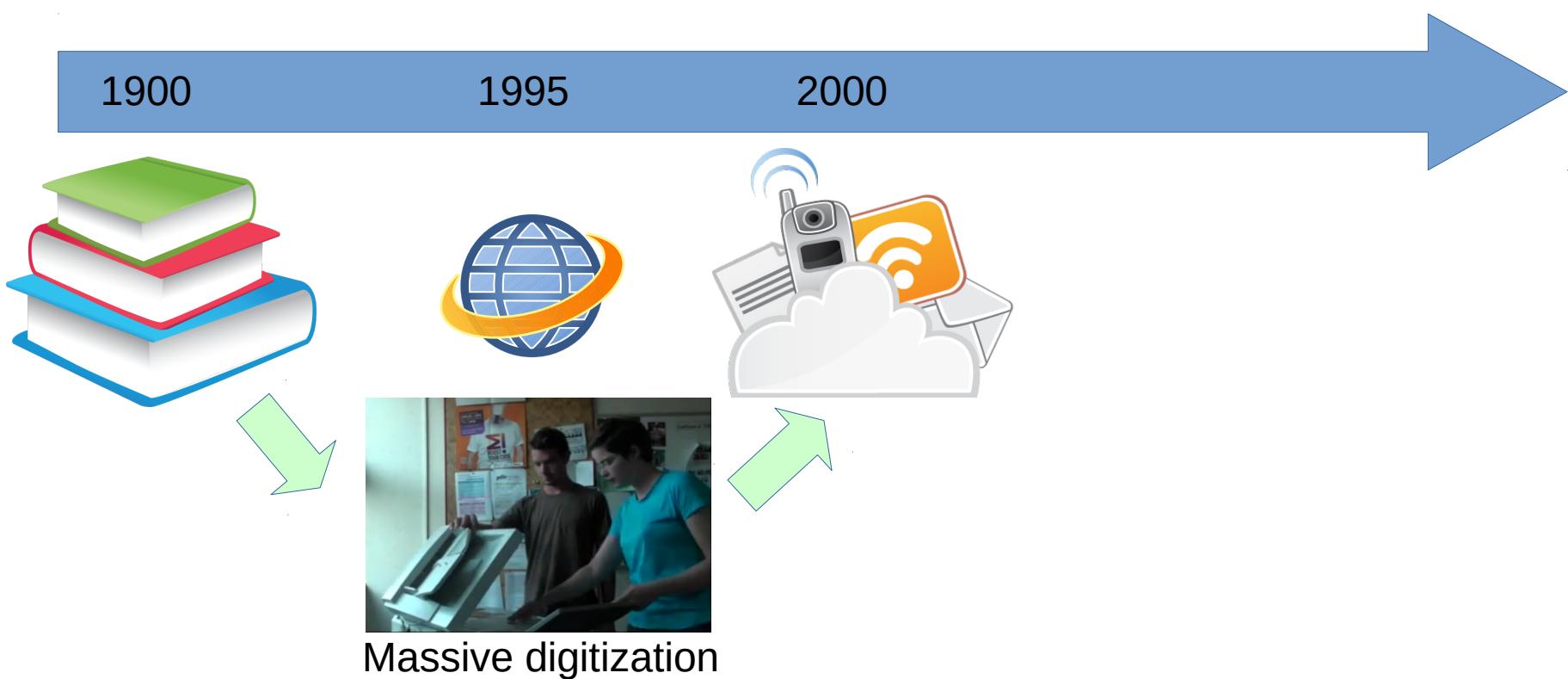
## Introduction

*“a visual medium used to express ideas via images, often combined with text or visual information”*

Wikipédia, 2014

*“One of the most popular and familiar forms of graphic content”*

Hiroaki Tobita, Sony CSL Interaction Laboratory, 2014



# Comic books

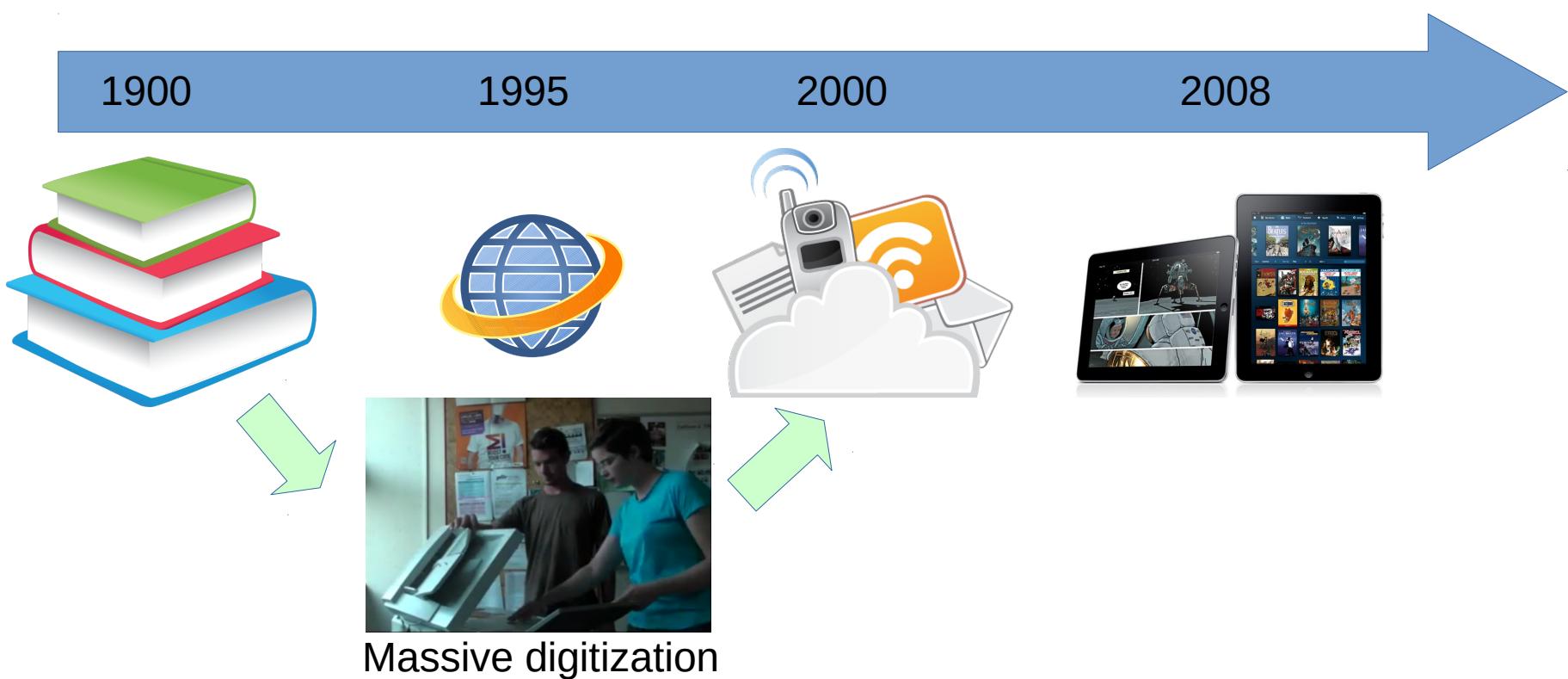
## Introduction

*“a visual medium used to express ideas via images, often combined with text or visual information”*

Wikipédia, 2014

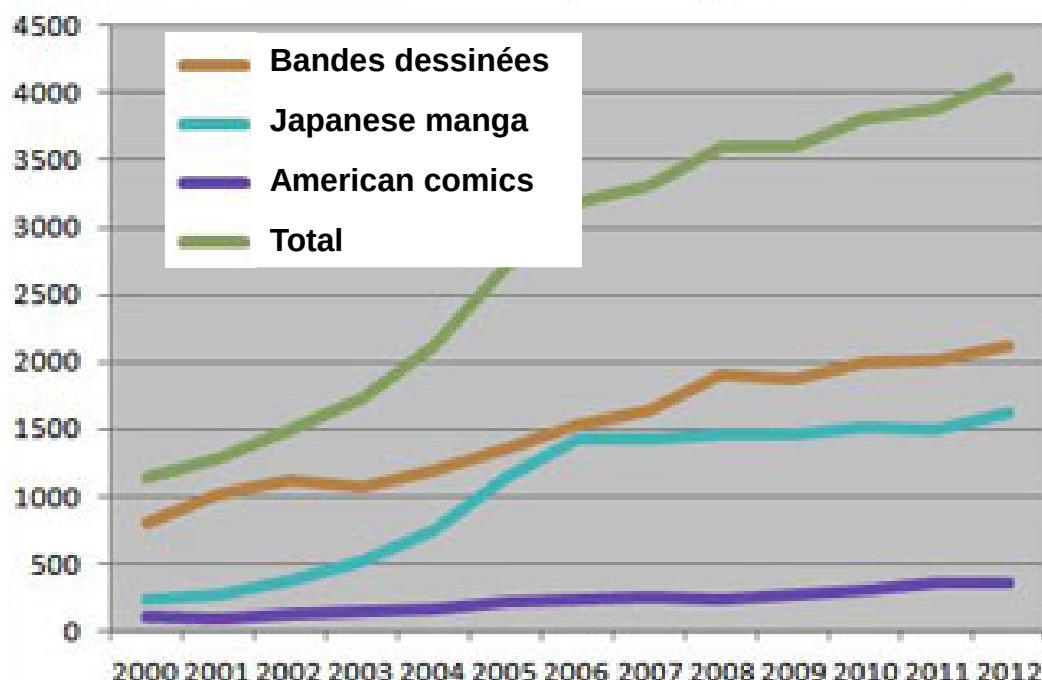
*“One of the most popular and familiar forms of graphic content”*

Hiroaki Tobita, Sony CSL Interaction Laboratory, 2014



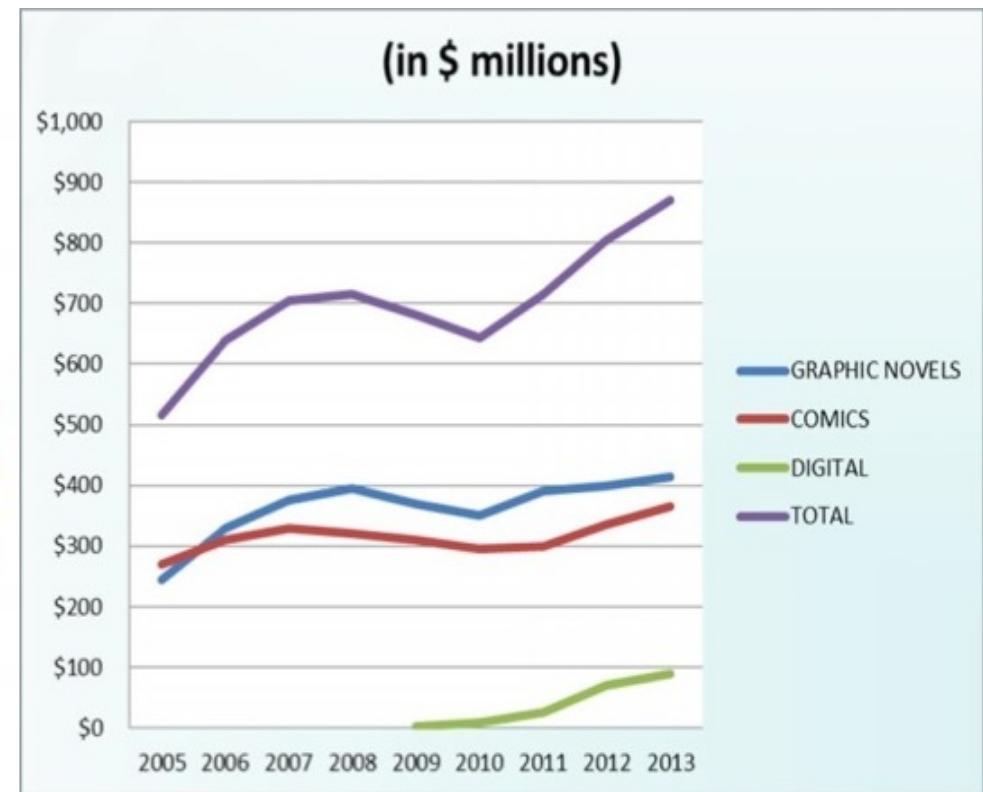
# Comic books

## Introduction



Francophone comics production

Infographie (c) L'Agence BD d'après les chiffres de Gilles Ratier/ACBD.



Comics market in the US

Milton Griepp's White Paper, ICv2 Conference 2014

# Context of the thesis

# Introduction

- eBDthèque project (since 2011)
  - Add value to digitized comics using the new technologies
  - Public founding CPER 2007-2013
  - 2 Ph.D. students, 1 engineer, 1 post doc, 6 professors
- Research axes
  - Content extraction (Christophe Rigaud)
  - Knowledge representation (Clément Guérin)
- Scientific challenges
  - mixed contents of a graphical and textual nature, semi-structured documents
  - authors are entirely free in their layout choices (few conventions widely adopted by comic book's authors in order to avoid the reader to be confused)
  - Content heterogeneity
  - intersection between semi-structured, free-form and complex background documents, combines their difficulties, increase complexity level
  - TODO (make challenges appear only on a second slide)
- Objectives
  - Segment image content
  - Retrieve inter-element relations
  - Provide a human-like interpretation
  -

- Comic book image analysis
- Content extraction
  - Panels
  - Balloons
  - Text
  - Comic characters



Pencil drawing. Image credits: Le cycle des bulles, Christophe Rigaud, 2012

# Comic book image analysis

## Background

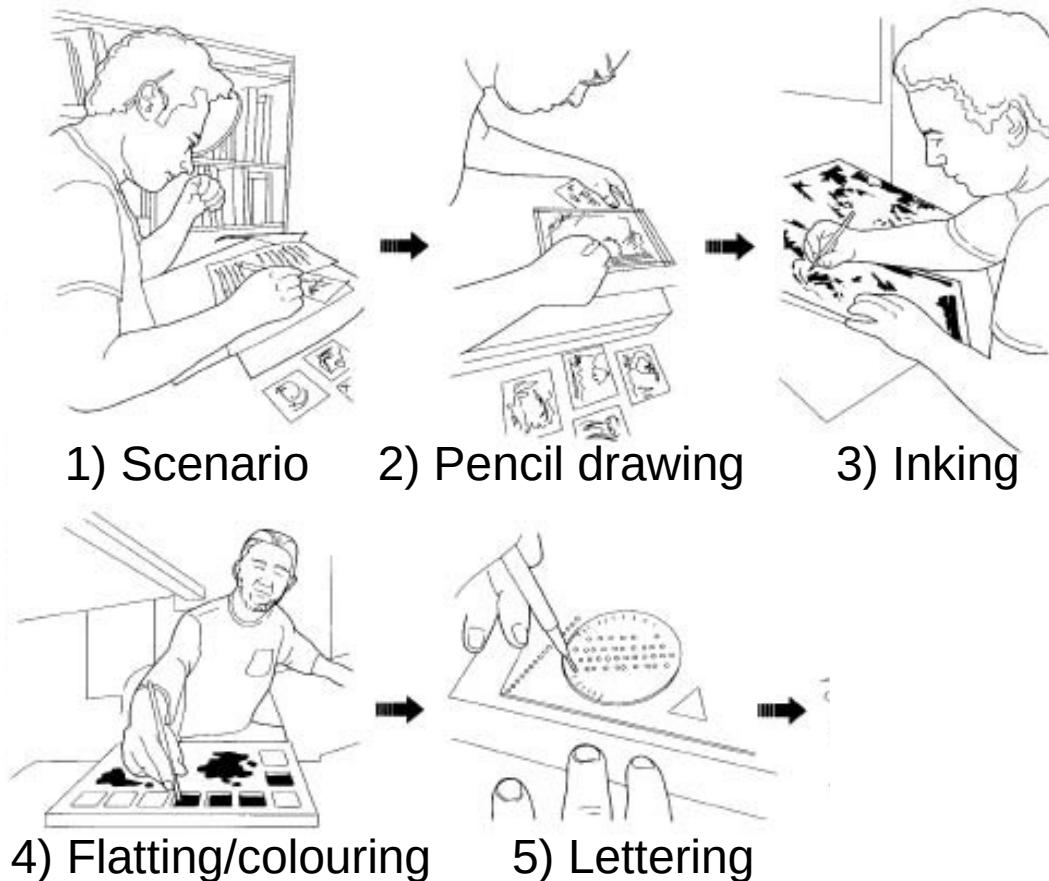
- Challenges:
  - Recent field of research with a **largely unknown**
  - **Semi-structured** and **free-form** document mixing text and graphics
- Design process:



# Comic book image analysis

## Background

- Challenges:
  - Recent field of research with a **largely unknown**
  - **Semi-structured** and **free-form** document mixing text and graphics
- Design process:



# Panel extraction

# Background

- Challenges

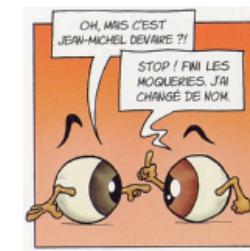
- Diversity of styles (gutter, implicit)
- Semi-structured layout

- Panel extraction

- White line cut [Chung07]
- Recursive X-Y cut [Eunjung07]
- Gradient [Tanaka07]
- Connected-components [Arai10, Pang14]
- Polygon detection [Li14a]
- Corners and line segments [Stommel12]

- Conclusions

- Problem solved for common manga and European comics if treated separately
- Remaining difficulties are for connected, nested and implicit panels
- No approach tested over all comics styles, no dataset, no reproductive results



# Panel extraction

# Background

- Challenges

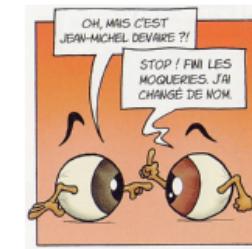
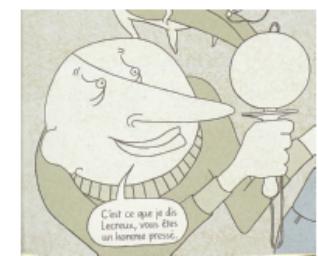
- Diversity of styles (gutter, implicit)
- Semi-structured layout

- Panel extraction

- White line cut [Chung07]
- Recursive X-Y cut [Eunjung07]
- Gradient [Tanaka07]
- Connected-components [Arai10, Pang14]
- Polygon detection [Li14a]
- Corners and line segments [Stommel12]

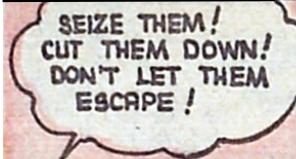
- Conclusions

- Problem solved for manga and other comics if treated separately
- Remaining difficulties are for connected, nested and implicit panels
- No public dataset, no reproductive results



# Balloon extraction

- Challenges
  - Shape and contour variations
  - Implicit balloons
- Extraction
  - Connected-components [Arai 2011, Ho 2012]
- Conclusions
  - Closed balloon solved (with text)
  - Implicit balloons, classification and tail to explore

Image	Shape	Contour
	Oval	Smooth
	Rectangle	Smooth
	Oval	Wavy
	Oval	Spiky
	Oval / implicit	Smooth / Implicit

# Balloon extraction

- Challenges
  - Shape and contour variations
  - Implicit balloons
- Extraction
  - Connected-components [Arai 2011, Ho 2012]
- Conclusions
  - Closed balloon solved (from text)
  - Implicit balloons, classification and tail are to explore

Image	Shape	Contour
	Oval	Smooth
	Rectangle	Smooth
	Oval	Wavy
	Oval	Spiky
	Oval / implicit	Smooth / Implicit

# Text extraction and recognition

## Background

- Challenges
    - Non-standard fonts
    - Multi-script/orientation/scale
    - Complex background (sound effects)
    - Hyphenation, voluntary spelling mistakes
  - Extraction
    - Connected-components [Ho12,??]
    - SVM and Bayesian classifier [Li14b]
  - Recognition
    - OCR trained for a specific comic font [Ponsard12]



# Text extraction and recognition

## Background

- Challenges
    - Non-standard fonts
    - Multi-script/orientation/scale
    - Complex background (sound effects)
    - Hyphenation, voluntary spelling mistakes
  - Extraction
    - Connected-components [Ho12, ???]
    - SVM and Bayesian classifier [Li14b]
  - Recognition
    - OCR trained for a specific comic font [Ponsard12]



- Conclusions
    - Speech text (from speech balloon)
    - Captions and sound effects unexplored
    - Text recognition very poor

# Comic character extraction

## Background

- Challenges

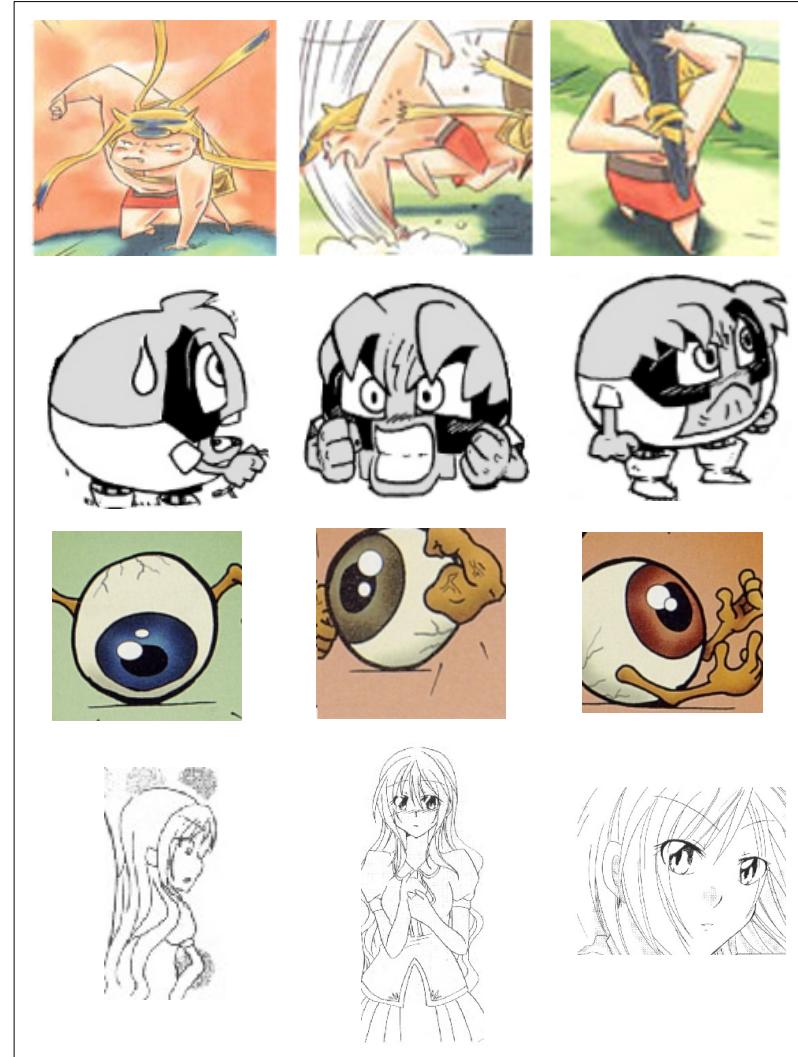
- Hand-drawn, stroke-based
- Intra/inter class variability
- Scale, deformation, posture, occlusion

- Extraction & recognition

- Manga faces [Cheung2008, Sun2010, Kohei2012]
- Cartoons [Khan2012]

- Conclusions

- Preliminary results
- Complex and versatile structure
- Contains most of the interesting information



# Comic character extraction

## Background

- Challenges

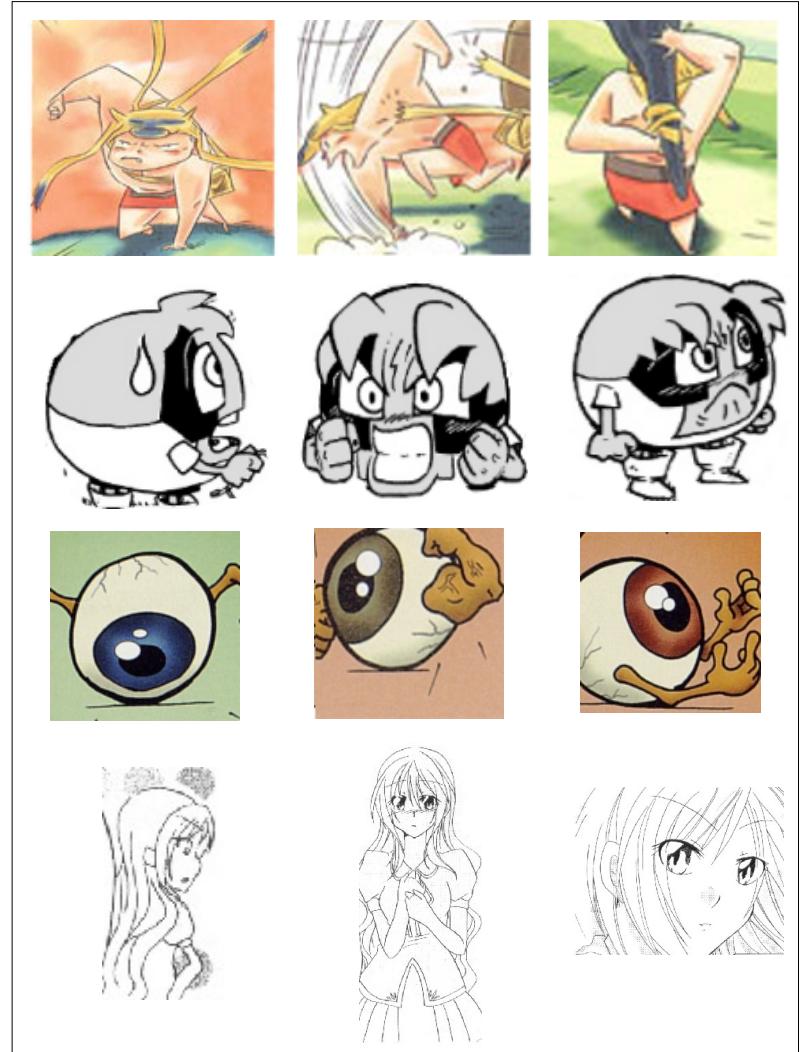
- Hand-drawn, stroke-based
- Intra/inter class variability
- Scale, deformation, posture, occlusion

- Extraction & recognition

- Manga faces [Cheung2008, Sun2010, Kohei2012]
- Cartoons [Khan2012]

- Conclusions

- Preliminary results
- Complex and versatile structure
- Contains most of the interesting information



# State progress

# Background

<b>Element</b>	<b>Process type</b>	<b>Advancement</b>
Panel	Localisation	80%
	Classification	0%
Balloon	Localisation	60%
	Classification	0%
Text	Localisation	50%
	Recognition	10%
Comic character	Localisation	10%
	Identification	10%
	Face/pose	0%
Context	Inter-element	0%
	Situation	0%
	Timestamps	30%
Dataset	Localisation	0%
	Semantic	0%

- Introduction
- Content-driven approach
- Knowledge-driven approach



Inking. Image credits: Le cycle des bulles,  
Christophe Rigaud, 2012

- **Introduction**
- Content-driven approach
- Knowledge-driven approach

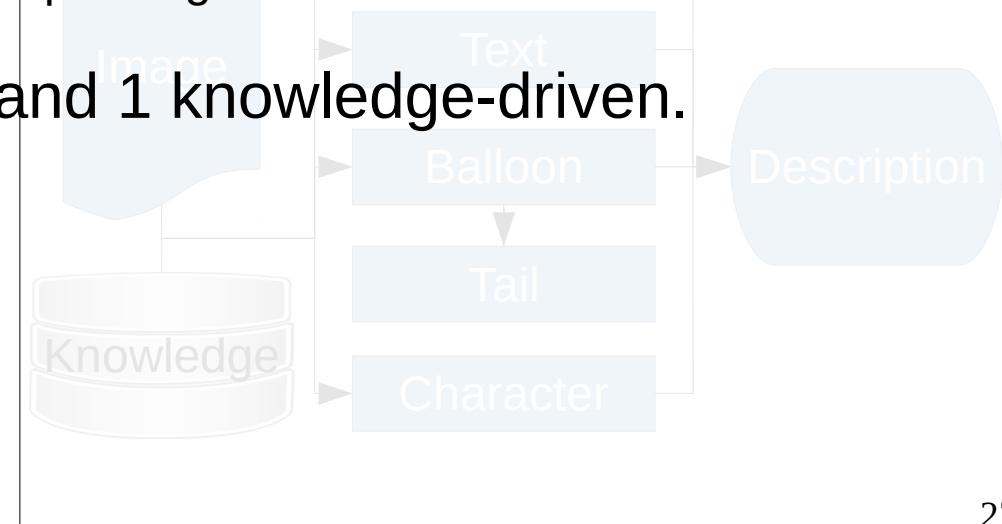
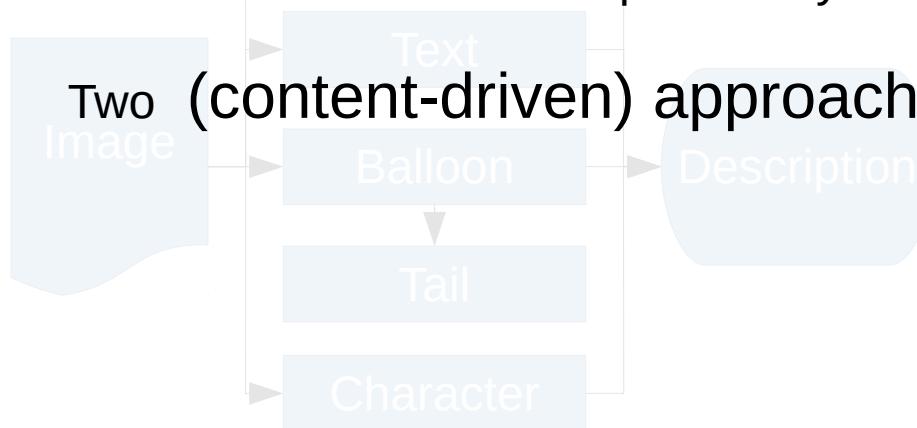


Inking. Image credits: Le cycle des bulles,  
Christophe Rigaud, 2012

## Content-driven (sequential)

In this thesis we propose three approaches in order to cover the widest possible scope of study, from a sequential and supervised approach to an knowledge-driven and unsupervised method. The first approach profits from the relations between elements to guide the retrieval process. For instance, the panels are first extracted then balloons containing text that are inside panels and finally comic character regions of interest are defined from the speech balloon tail indications. This approach is quite intuitive but also very sensitive to error propagation issue between the different extraction steps [8,67]. The second approach consists in making the extraction independent from each other, in order to avoid error propagation issues. The third proposition adds contextual information to the independent extractions. The context is retrieved by matching extracted element relations with a generic model of the domain knowledge. This last approach allows a semantic description of the images. For instance, text regions that are detected inside balloons are inferred as being speech text regions and comic characters that are pointed by a tail as speaking characters.

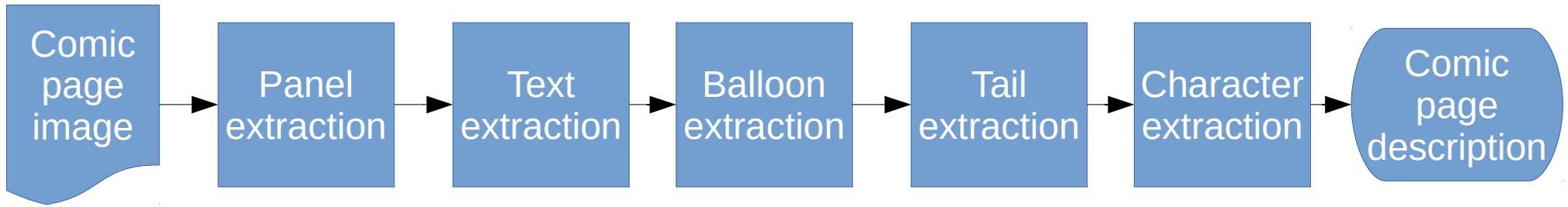
## Two (content-driven) approaches and 1 knowledge-driven.



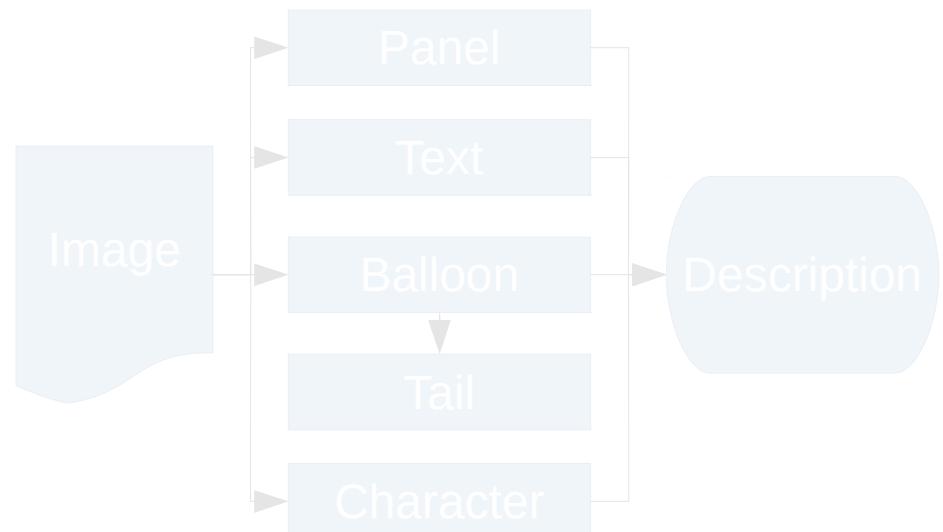
Element	Process type	Analysis method	Method	Publication	Before	After	$\Delta$
Panel	Localisation	Histogram	S	CIFED'12 LNCS'13	80%	90%	<b>+10%</b>
		Topology	I, K	IJDAR'15			
Balloon	Localisation	Topology	S	-	60%	80%	<b>+20%</b>
		Region	I, K	-			
		Edge	S	ICDAR'13			
	Classification	Contour	S, I, K	GREC'13 LNCS'14	0%	80%	<b>+80%</b>
Text	Localisation	Topology	S		50%	70%	<b>+20%</b>
		Structure	I, K	VISAPP'13			
	Recognition	-	-	-	10%	10%	0%
Comic characters	Localisation	Graph	-	GREC'13 (2nd)	10%	20%	<b>+10%</b>
		Context	S, K	CIFED'14 RFIA'14 (2nd)			
		Spotting	Colour	I			
	Identification	-	-	-	10%	10%	0%
	Face/pose	-	-	-	0%	0%	0%
Context	Inter-element	Proximity	S, K	CIFED'14 RFIA'14 (2nd) IJDAR'15	0%	10%	<b>+10%</b>

- Approaches

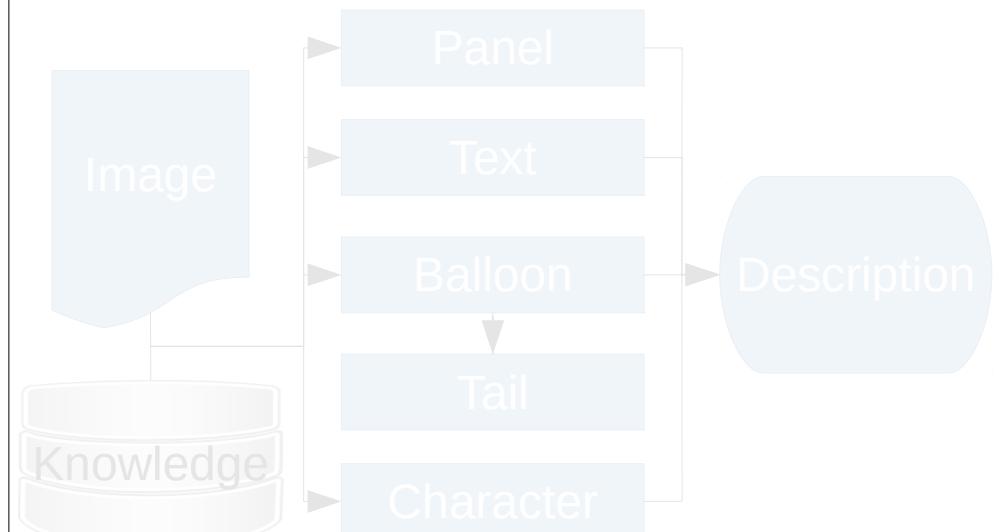
### Sequential



### Independent

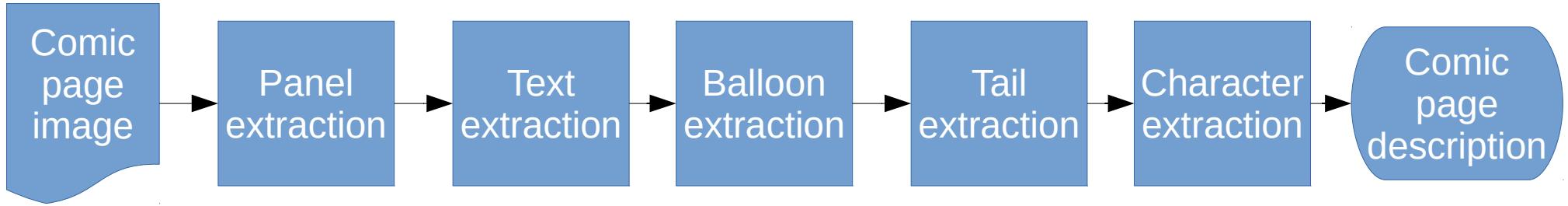


### Knowledge-driven

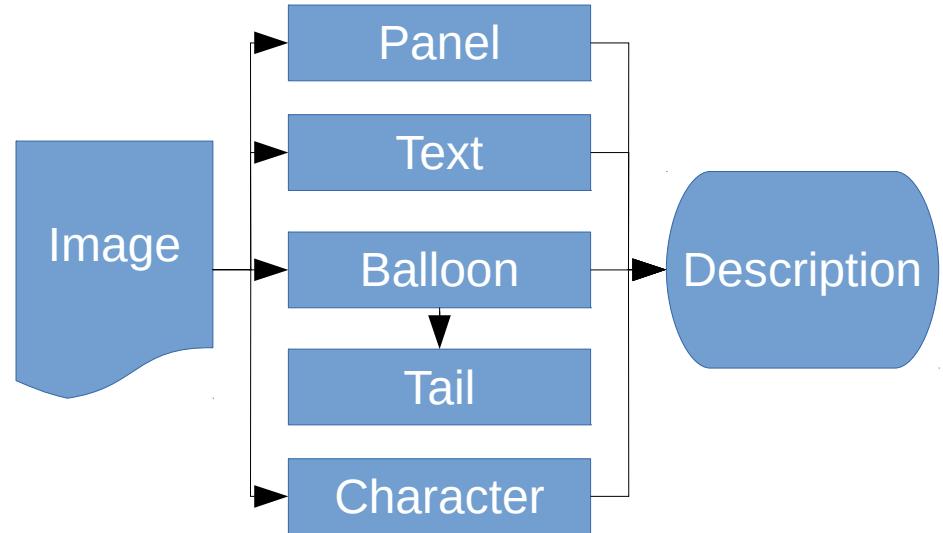


- Approaches

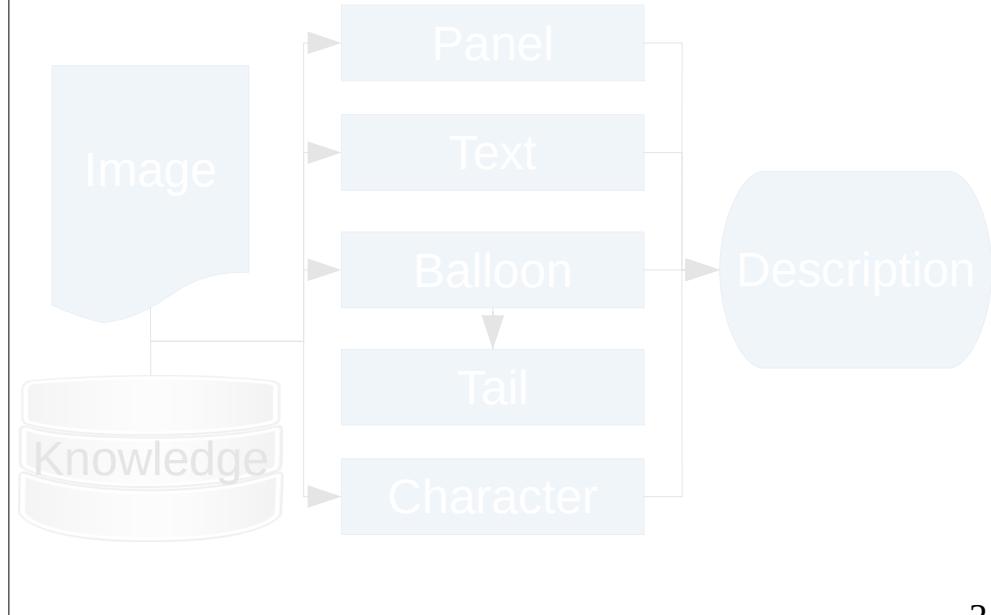
### Sequential



### Independent

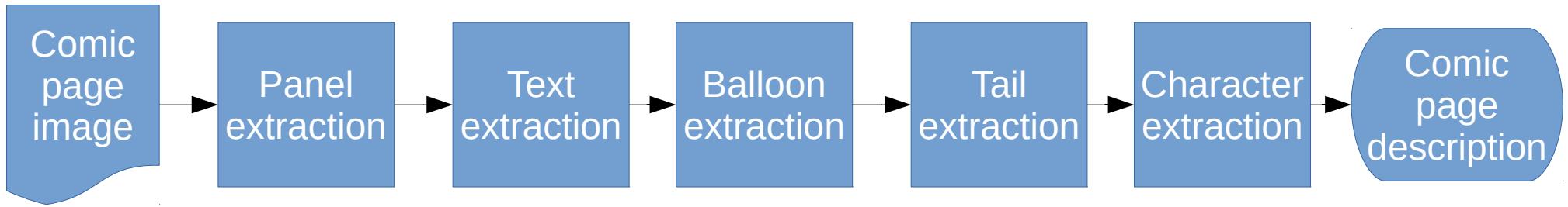


### Knowledge-driven

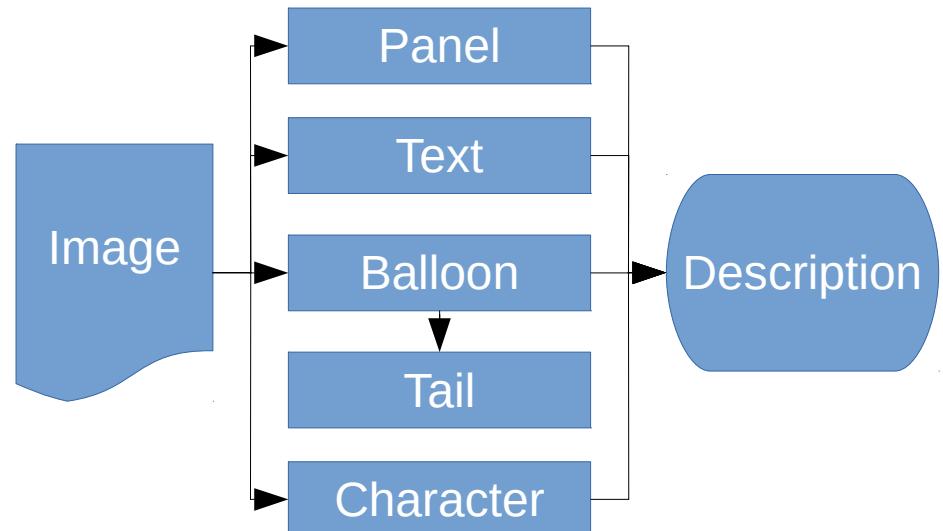


- Approaches

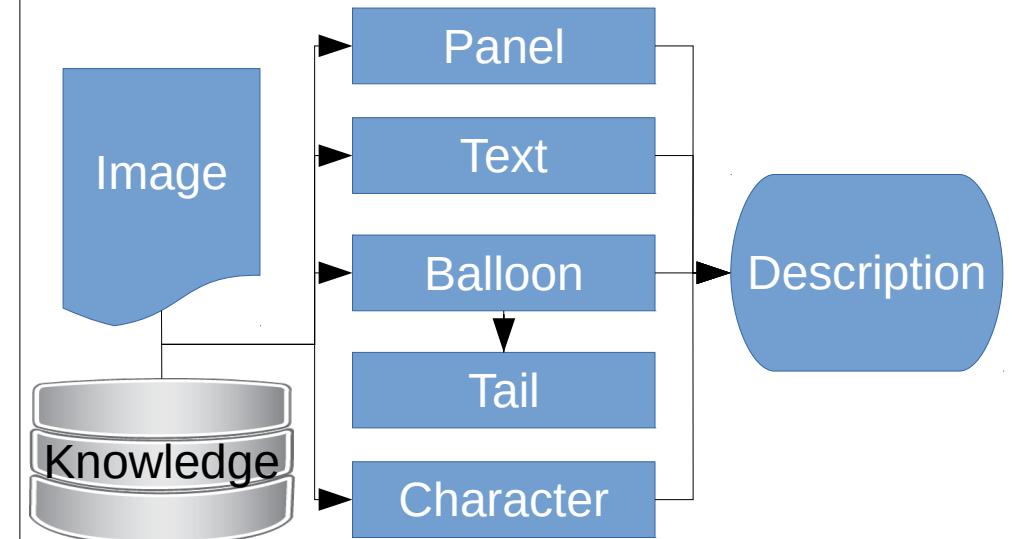
### Sequential



### Independent



### Knowledge-driven



- Introduction
- Content-driven approach (sequential)
- Knowledge-driven approach

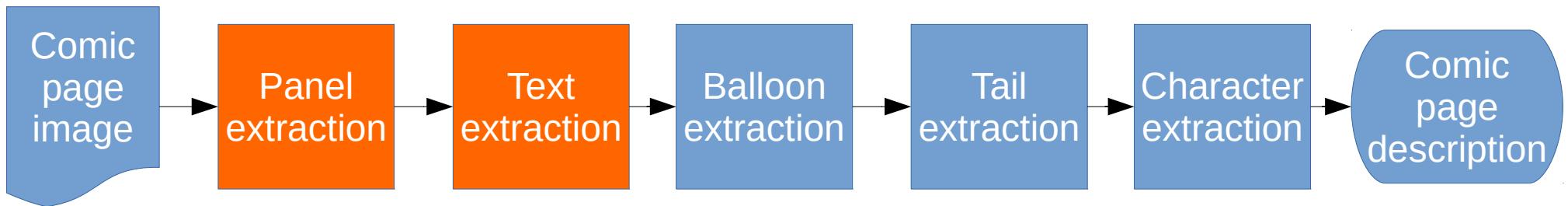


Inking. Image credits: Le cycle des bulles,  
Christophe Rigaud, 2012

# Panel and text extraction

Contributions  
Content-driven approach

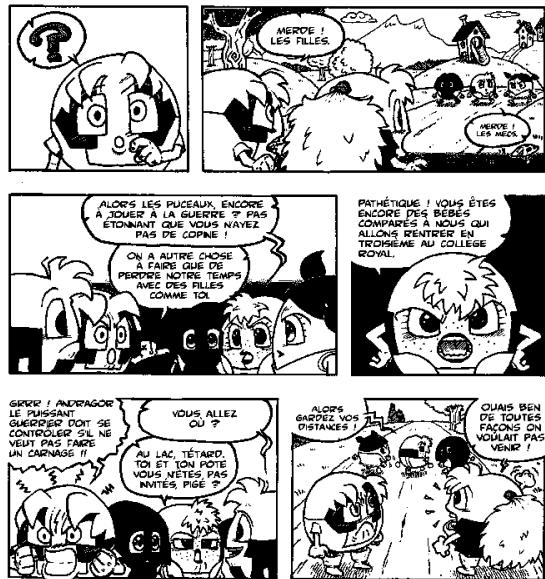
- Processing sequence



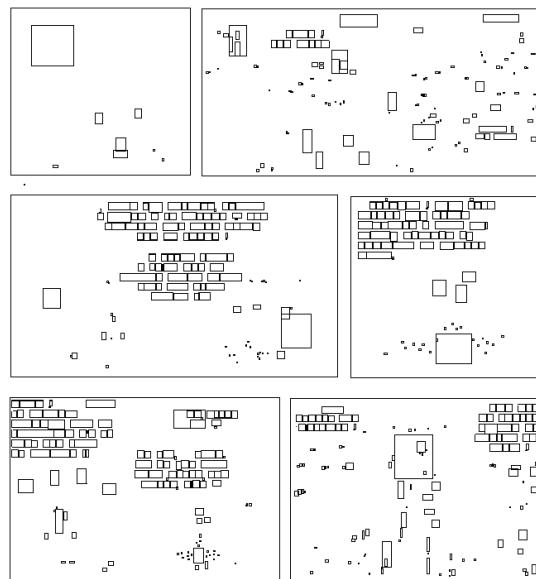
- Literature
  - Sequential or separated panel and text extraction
  - With or without gutters
- Contribution
  - Simultaneous panel and text extraction
  - Implicit and with gutters

# Panel and text extraction

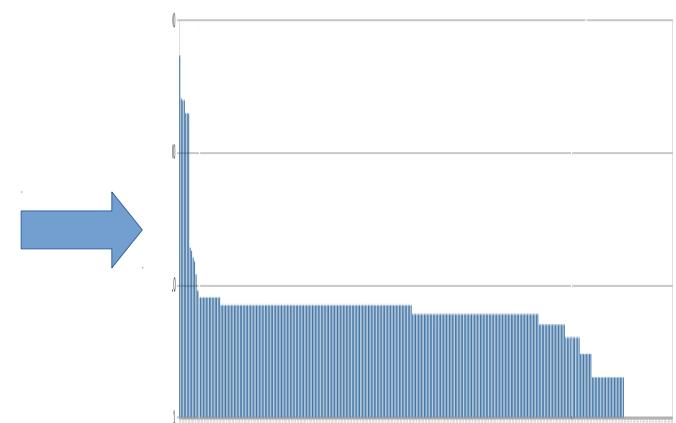
Contributions  
Content-driven approach



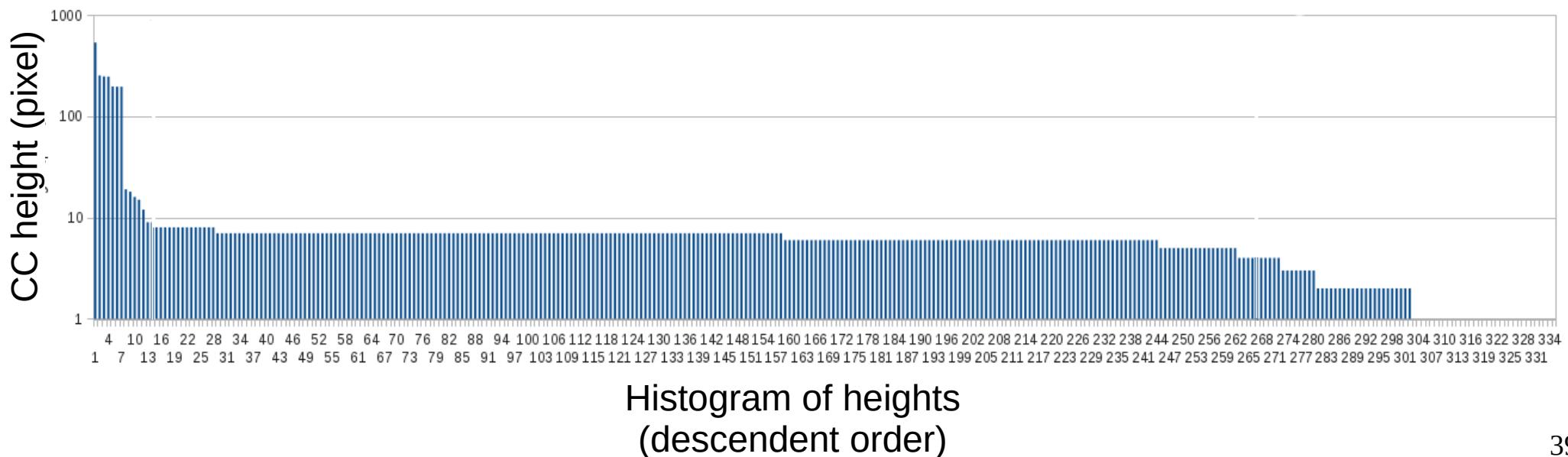
Binary image



Connected-component (CC) bounding boxes



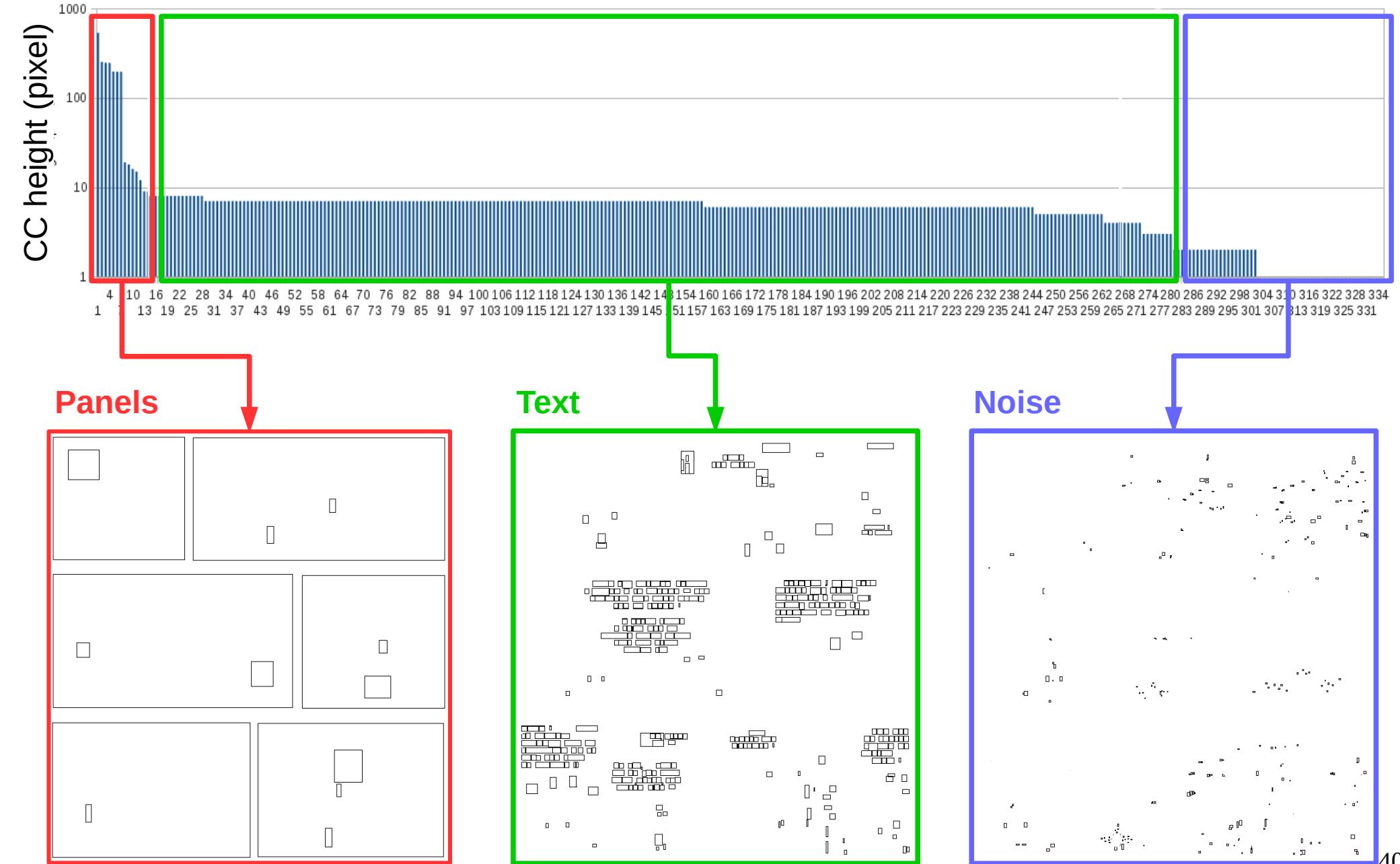
Histogram of heights of CC



# Panel and text extraction

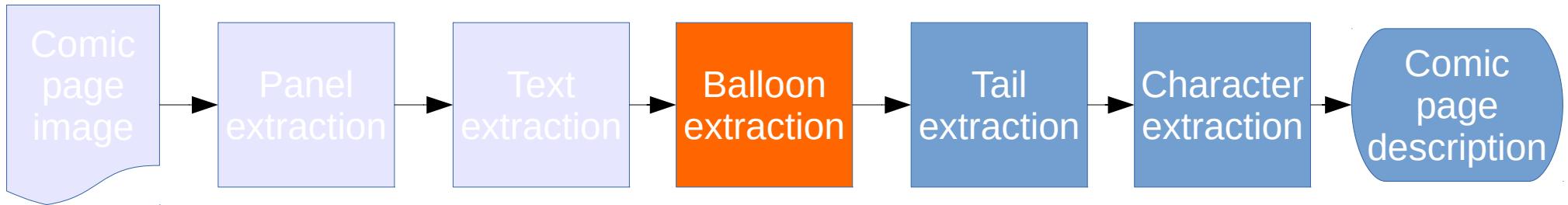
Contributions  
Content-driven approach

K-means clustering ( $k=3$ )



# Balloon extraction

Contributions  
Content-driven approach



Regular balloon

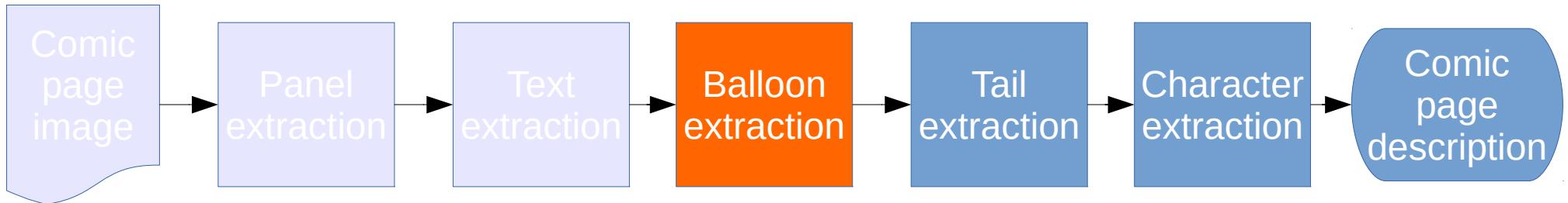


Implicit balloon

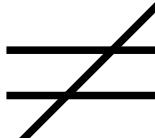
- Literature
  - Top-down approaches: extract white blobs and then text inside
  - Limited to regular balloons
- Contribution
  - Bottom-up approaches: extract text and then surrounding balloons
  - Appropriate for regular and implicit balloons

# Balloon extraction

Contributions  
Content-driven approach



Regular balloon



Implicit balloon

- Literature
  - Top-down approaches: extract white blobs and then text inside
  - Limited to regular balloons
- Contribution
  - Bottom-up approaches: extract text and then surrounding balloons
  - Improvement of regular and a first approach for implicit balloon extractions

# Balloon extraction: regular

Contributions  
Content-driven approach

- Assumptions
  - Panels and text block positions are known
  - Balloons contain centred text
- Proposition → structural analysis
  - Extract closed contours that includes centred text



Original image



Expected result

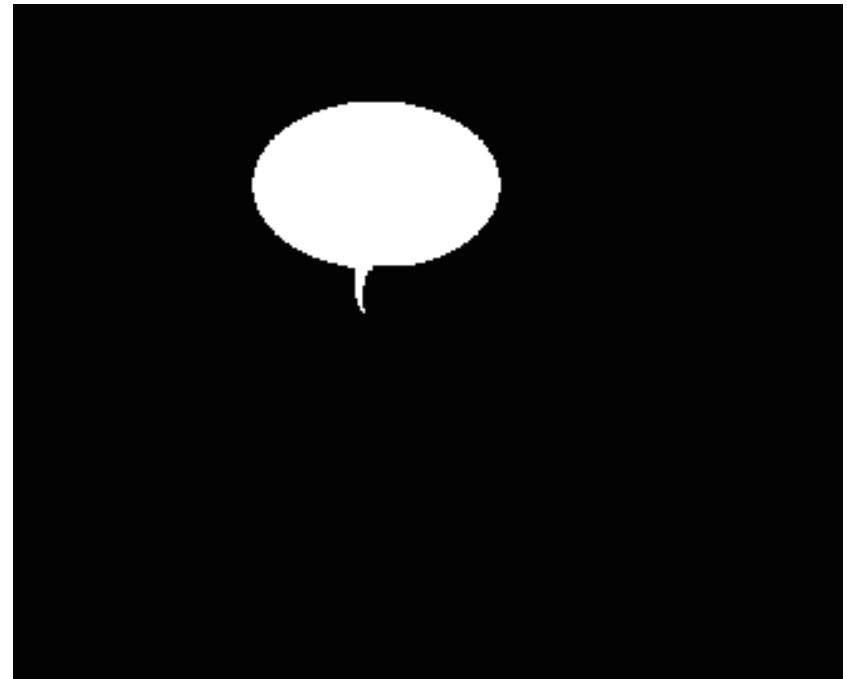
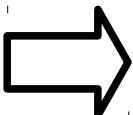
# Balloon extraction: regular

Contributions  
Content-driven approach

- Assumptions
  - Panels and text block positions are known
  - Balloons contain centred text
- Proposition → structural analysis
  - Extract closed contours that includes centred text



Original image



Expected result

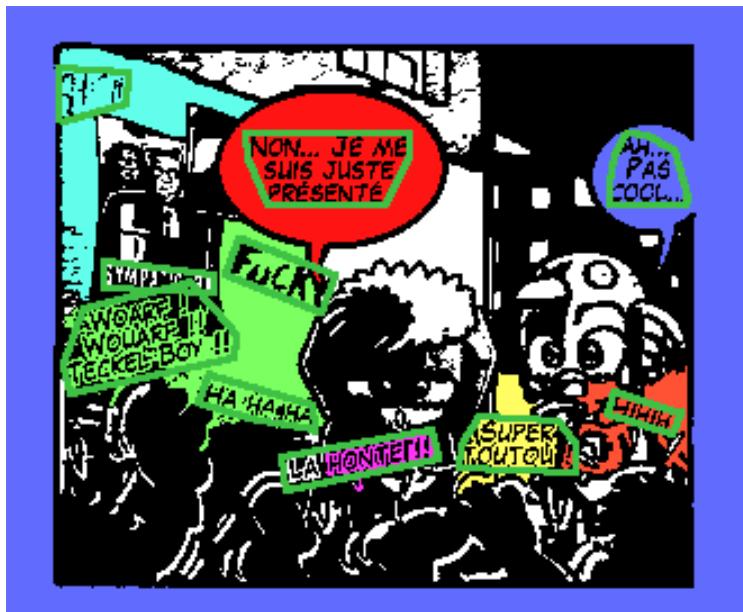
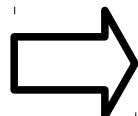
# Balloon extraction: regular



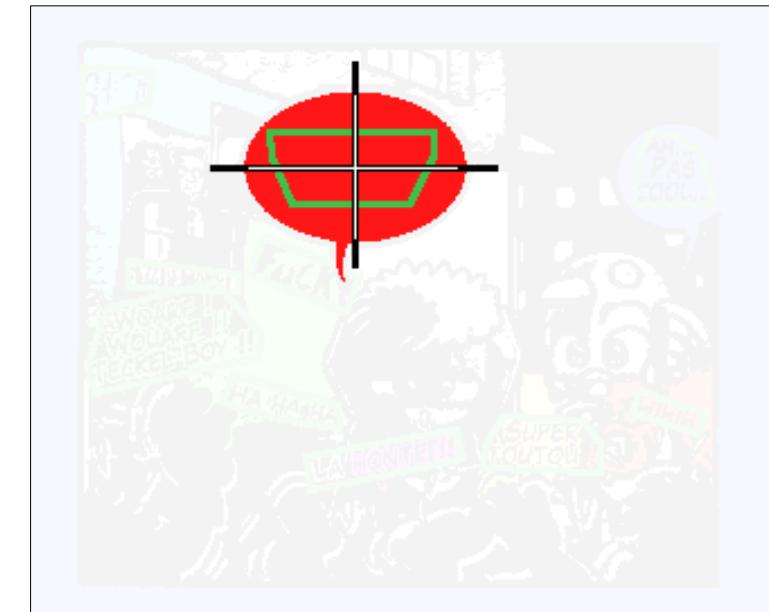
Original image



Text block positions (green)



Regions including text blocks (coloured)



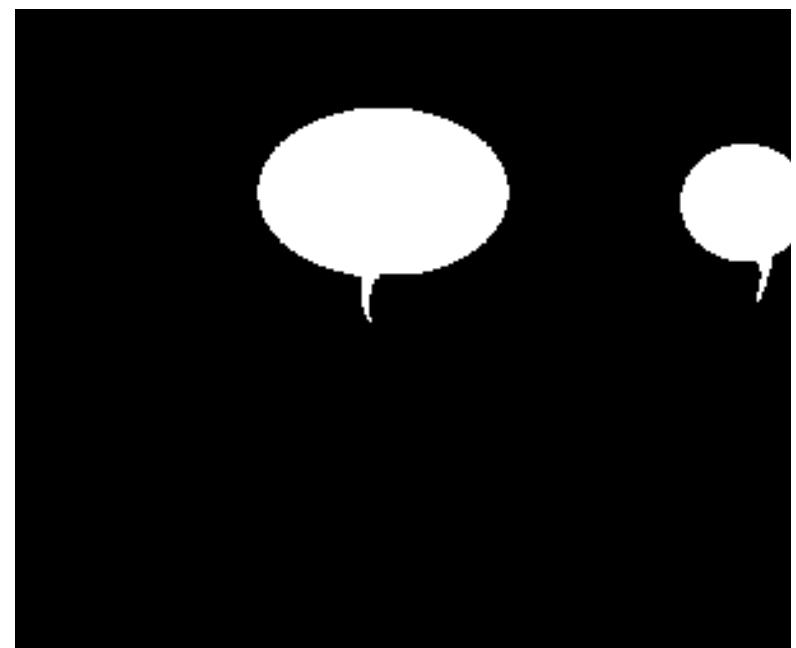
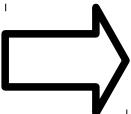
Regions including aligned text blocks

Contributions  
Content driven approach

# Balloon extraction: implicit

Contributions  
Content-driven approach

- Assumptions
  - Panel and text blocks positions are known
  - Implicit balloons contain centred text
- Proposition
  - Extract implicit balloons from text regions by inflating a deformable contour
  - Adaptation of active contour model (snake)

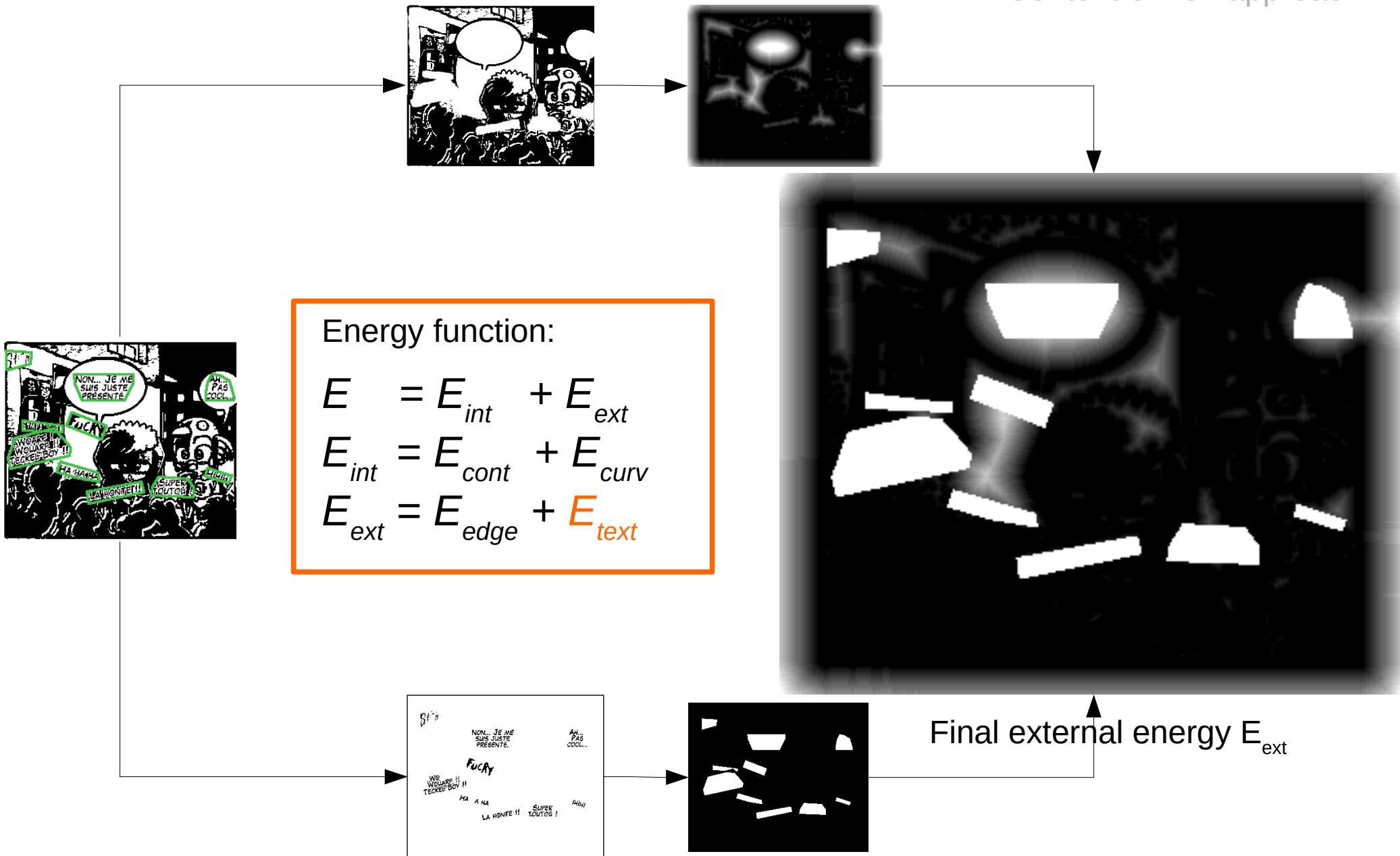


Original image and text locations

Expected result

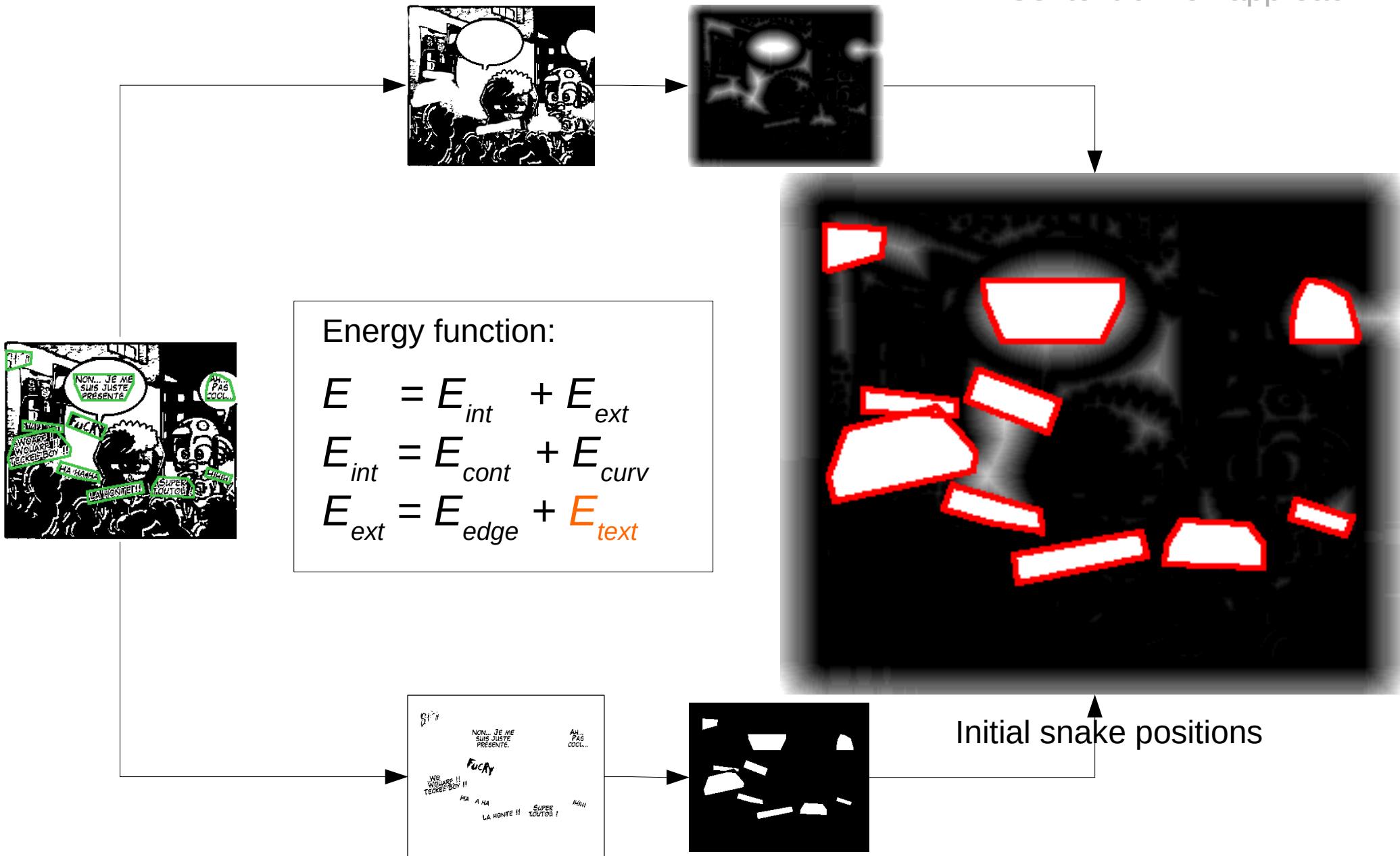
# Balloon extraction: implicit

Contributions  
Content-driven approach



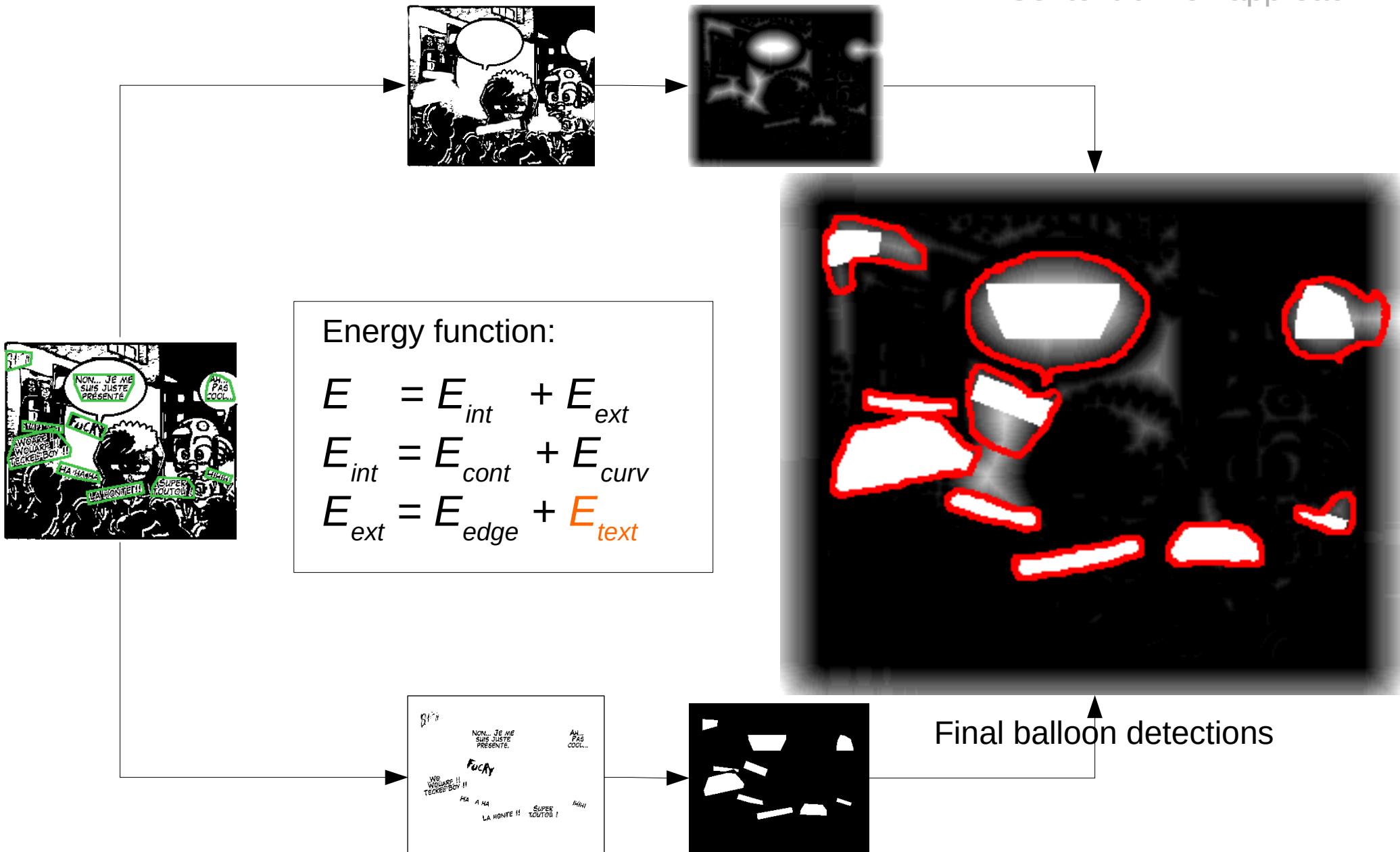
# Balloon extraction: implicit

Contributions  
Content-driven approach



# Balloon extraction: implicit

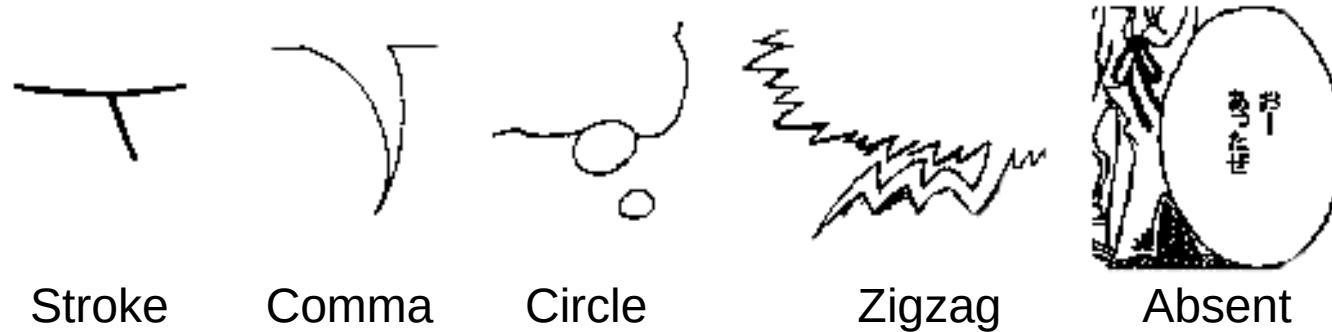
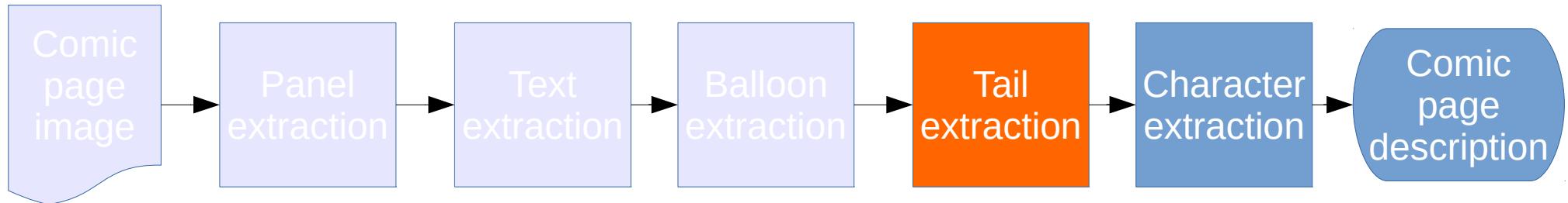
Contributions  
Content-driven approach



The snake is attracted to the “dark side”

# Tail extraction

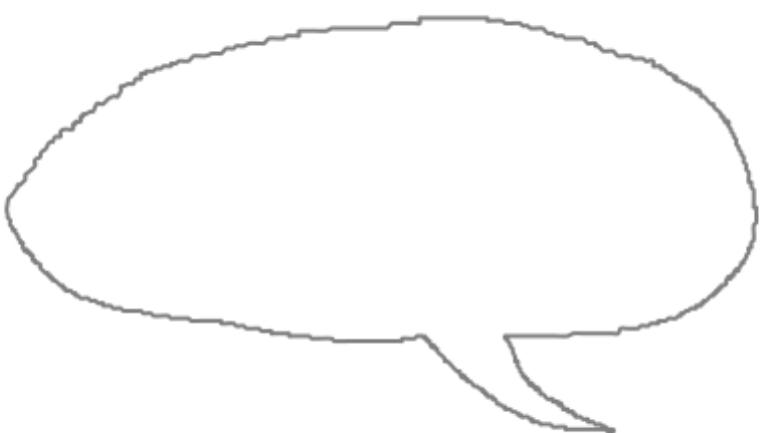
Contributions  
Content-driven approach



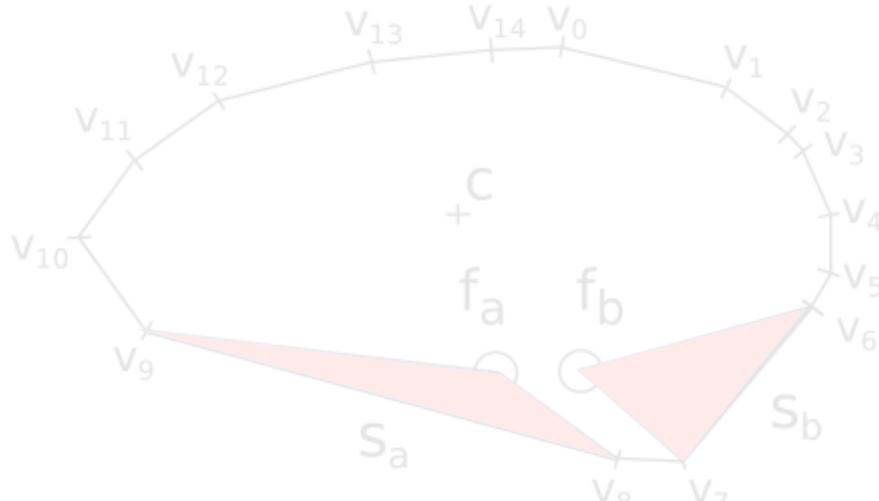
- Literature
  - First time studied in document image analysis
- Objectives
  - Detection of the tail tip position and orientation
  - Focus on comma, zigzag and absent types

# Tail extraction: tip position

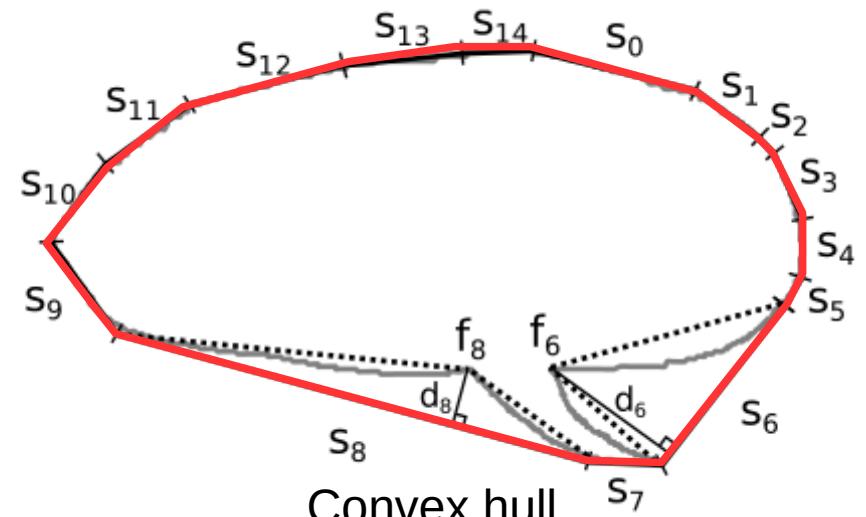
Contributions  
Content-driven approach



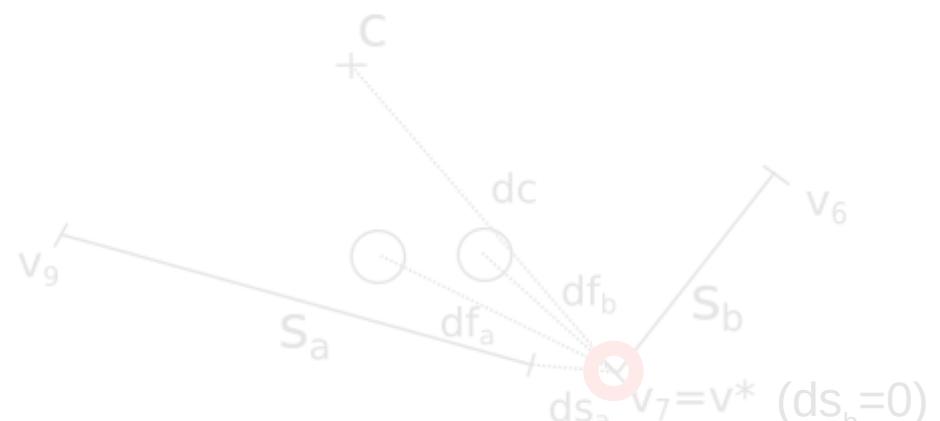
Balloon contour



Two biggest  
convexity defects



Convex hull



Tail tip position

Optimal vertex selection:

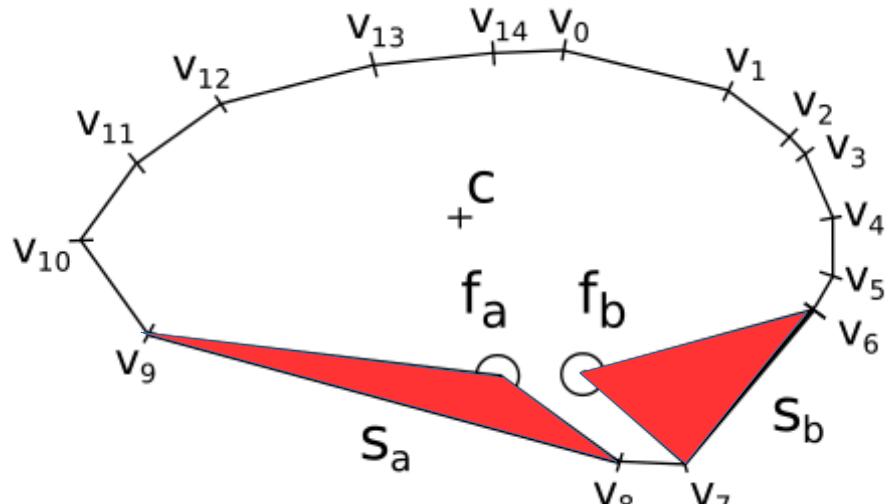
$$v^* = \operatorname{argmax}(\max(dc + df_a + df_b) + \min(ds_a + ds_b))$$

# Tail extraction: tip position

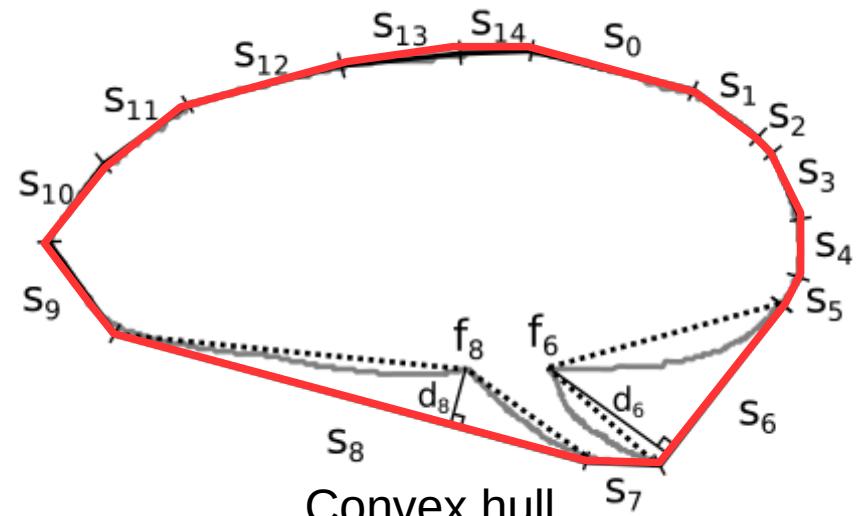
Contributions  
Content-driven approach



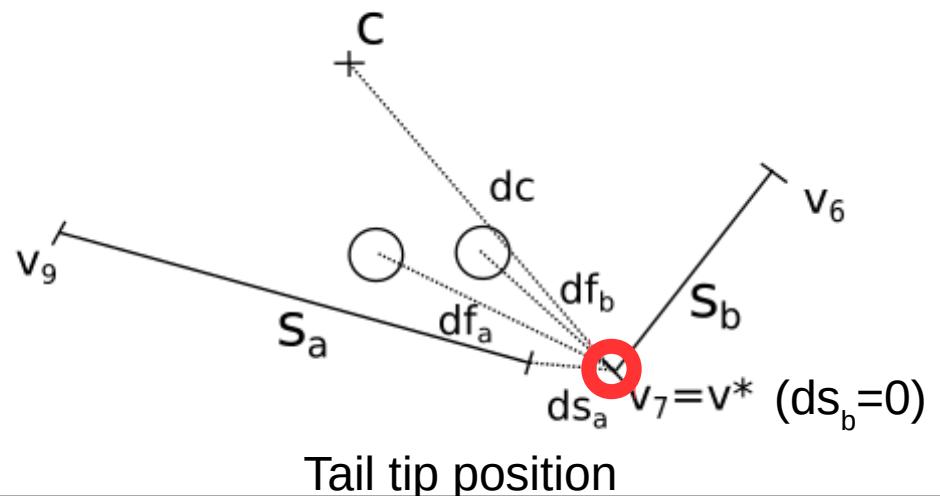
Balloon contour



Two biggest  
convexity defects



Convex hull



Tail tip position

Optimal vertex selection:

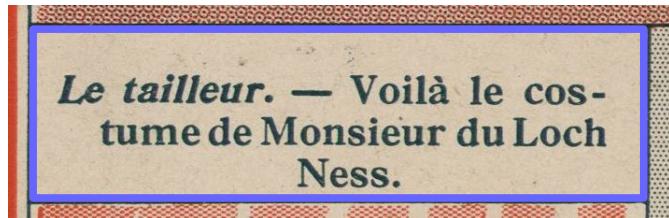
$$v^* = \operatorname{argmax}(\max(dc + df_a + df_b) + \min(ds_a + ds_b))$$

# Tail extraction: confidence value

Contributions  
Content-driven approach

Balloon  
contour (blue)

Balloon 1

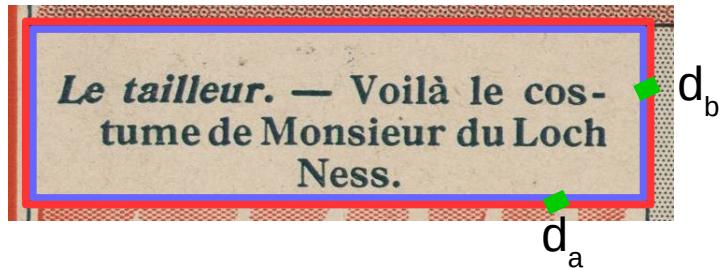


Convex hull  
(red)

Balloon 2



Confidence



$$C_{tail} = \frac{(d_a + d_b)/2}{meanBalloonSize}$$

$$C_{tail} = 0.0$$

Presence of tail

NO

$$C_{tail} = 0.73$$

YES (>0)

# Tail extraction: tail direction

Contributions  
Content-driven approach

- Definition
  - Vector starting from “background” to “external edge” tail tip positions
- Approach
  - Extract external edge
  - Find external edge tail tip coordinates
  - Define the tail direction (N, NE, E, SE, S, SW, W, NW)



Background tail tip  
(green) and  
external edge (blue)



Closest point on  
external edge  
(red)



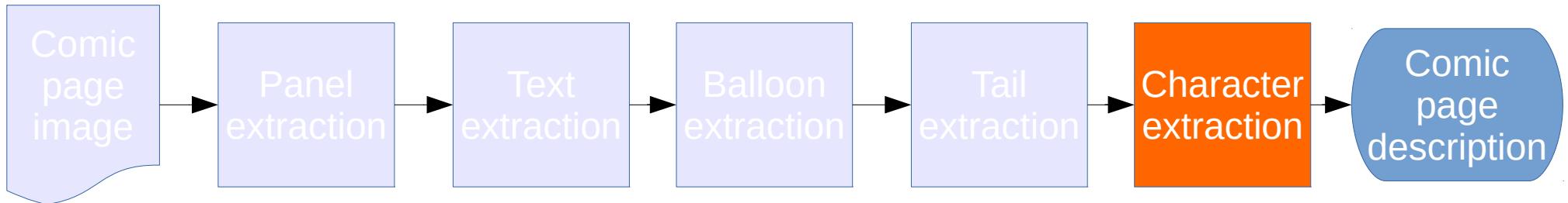
Farthest point  
from origin and tip  
(red)



Direction from tip  
to farthest point  
(white arrow)

# Comic character extraction

Contributions  
Content-driven approach

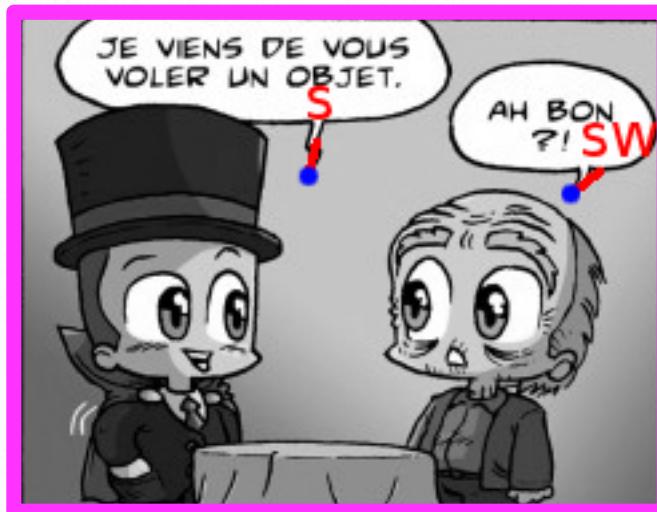


- Literature
  - Supervised approaches for manga and cartoon characters [TODO]
  - No public dataset (copyright issues)
- Challenges
  - Variety of styles of comic books
  - Intra and extra class variations of each character instance (e.g. position, scale, pose, occlusion and human-like, invented)
- Objective
  - Unsupervised and generic approach for all styles of comic books

# Comic character extraction

Contributions  
Content-driven approach

Panels + Tails = ?



# Comic character extraction

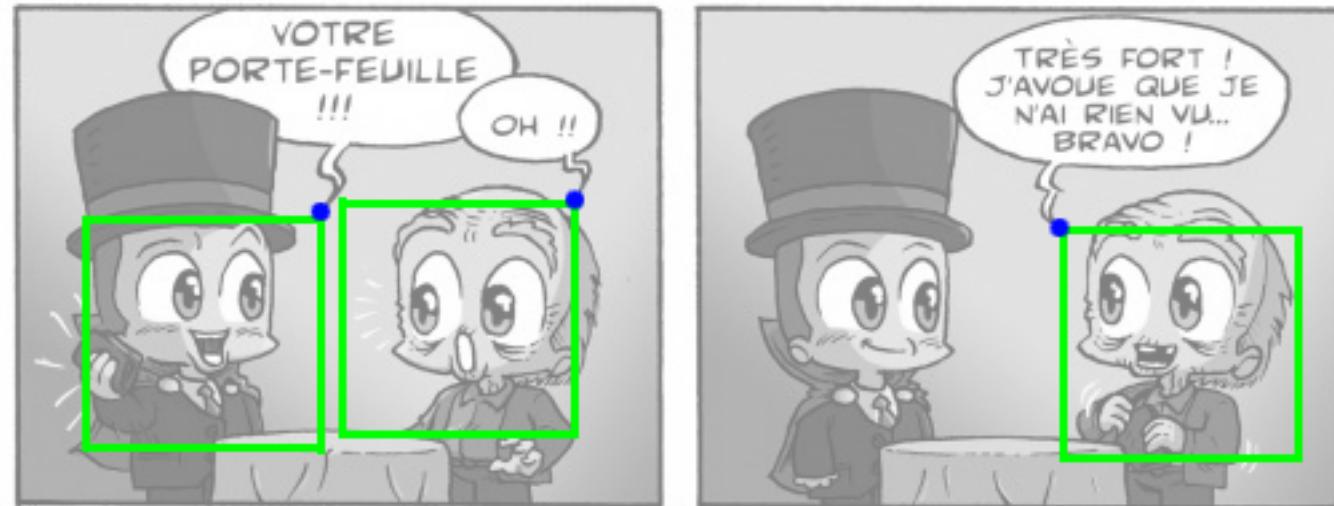
Contributions  
Content-driven approach

Panels + Tails = Comic character ROIs

Large ROI



Small ROI



- Introduction
- Content-driven approach
- Knowledge-driven approach



Inking. Image credits: Le cycle des bulles,  
Christophe Rigaud, 2012

# Introduction

- High level image description
- Independent element extraction
- Framework for comics understanding
- Collaboration with Clément Guérin

# Contributions

Knowledge-driven approach

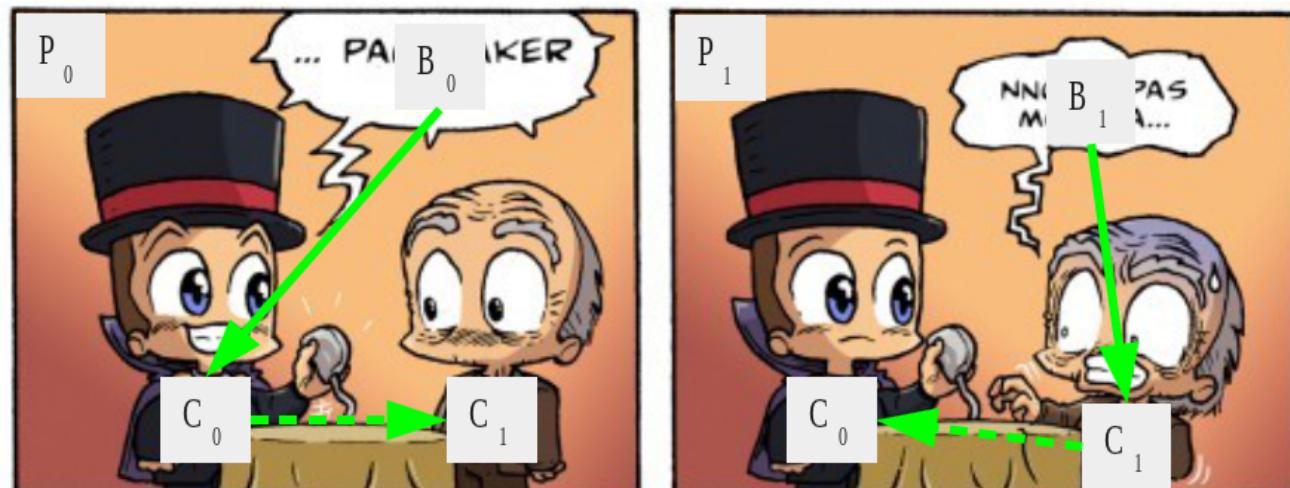
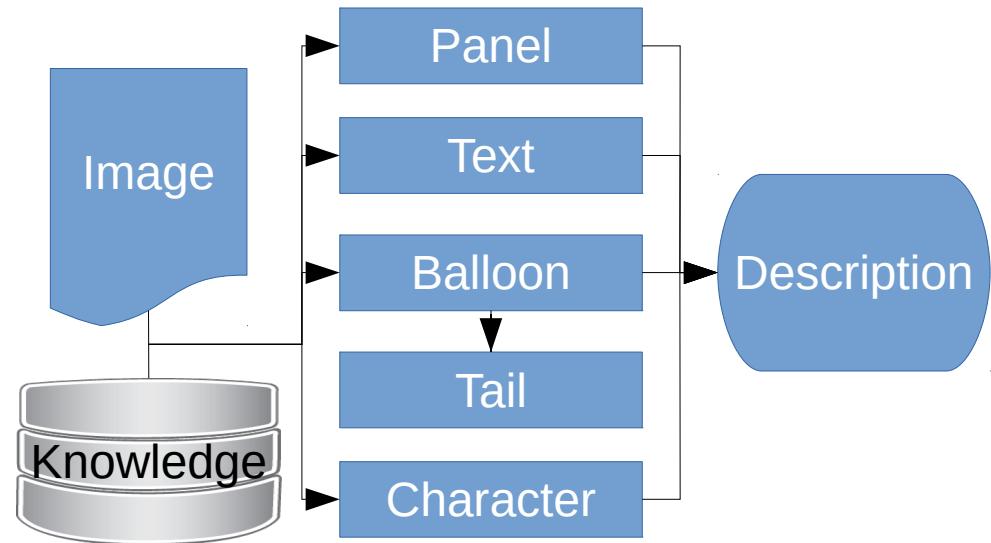
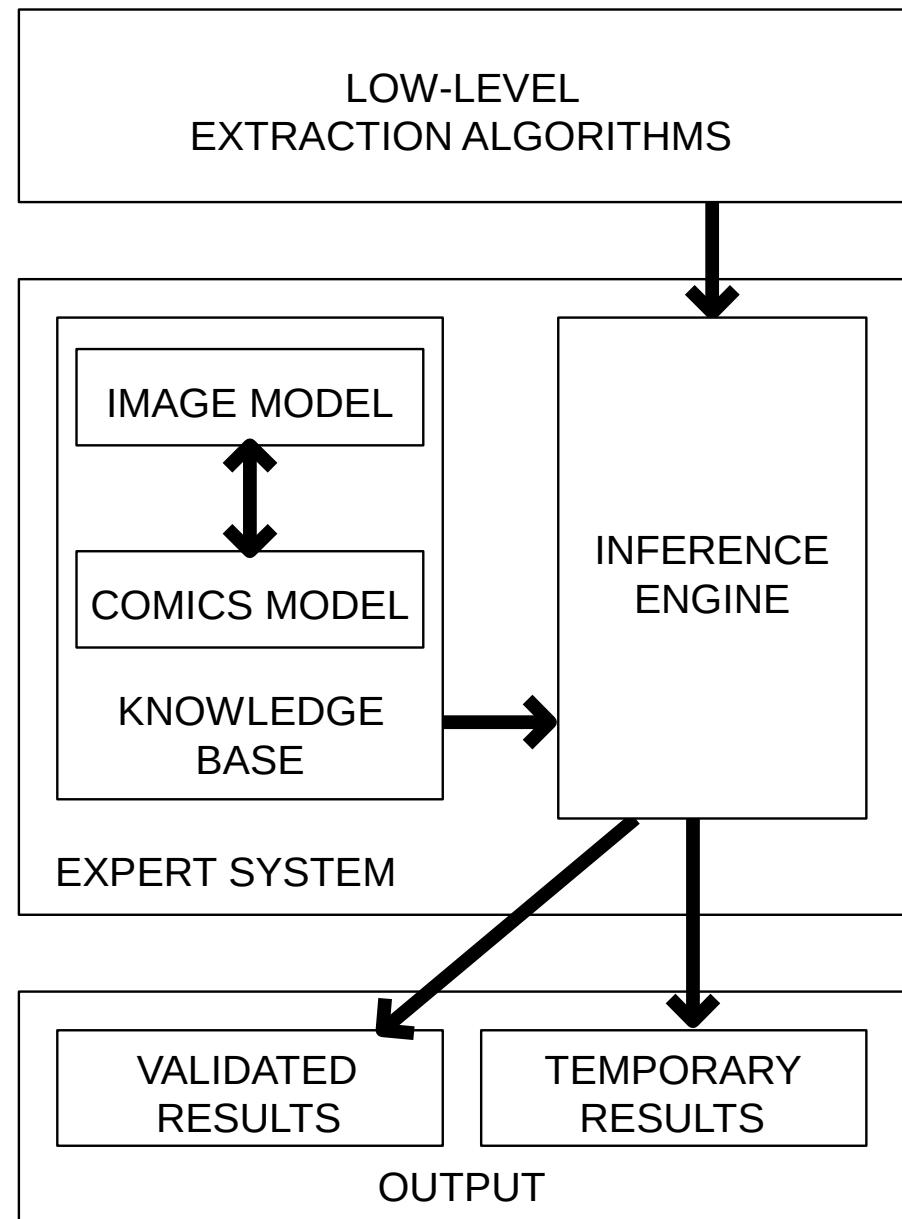


Illustration of high level description

# Knowledge representation

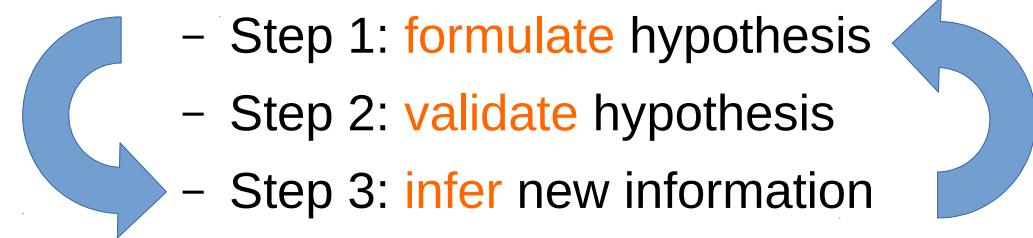
- Image model
  - Physical support
  - Region of interests
- Comics model
  - Validations
    - A panel **P** is related to one page
    - A balloon **B** is related to one panel and may have a tail **Q**
    - A character **C** is related to one panel
    - A text line **T** is related to one balloon
  - Inferences
    - **B + Q + T => speech balloon SB**
    - **SB + T => speech text ST**
    - **SB + C => speaking character SC**



# Processing sequence

- Process loop

- Step 1: **formulate** hypothesis
  - Step 2: **validate** hypothesis
  - Step 3: **infer** new information



- Study case

- Iteration 1
    - Step 1: hypotheses of **simple element** positions
    - Step 2: validation of the positions
    - Step 3: inference a new information
  - Iteration 2
    - Step 1: hypotheses of **more complex** elements
    - Step 2: validation of the positions
    - Step 3: inference a new information
  - ...

# Contributions

Knowledge-driven approach



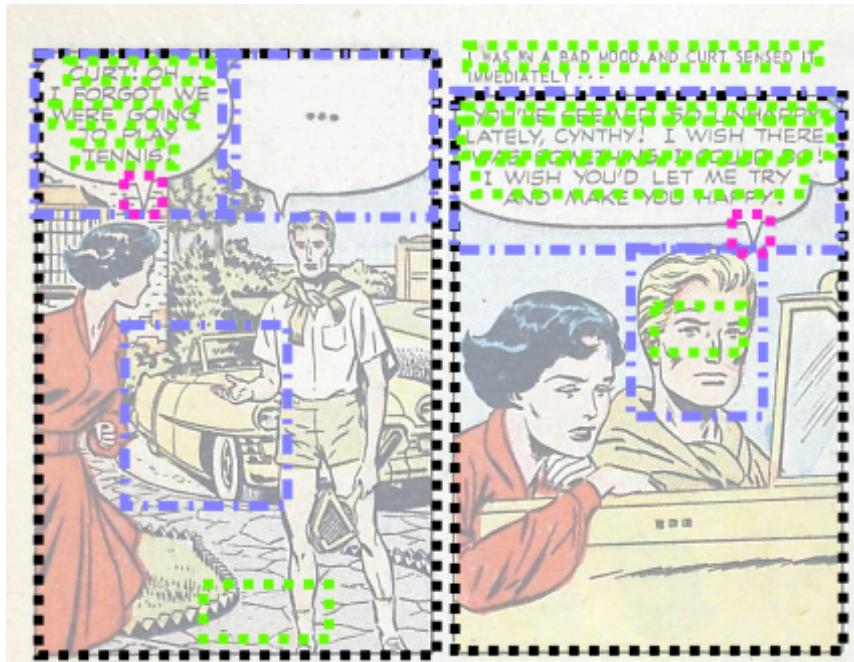
# Processing sequence

Contributions  
Knowledge-driven approach

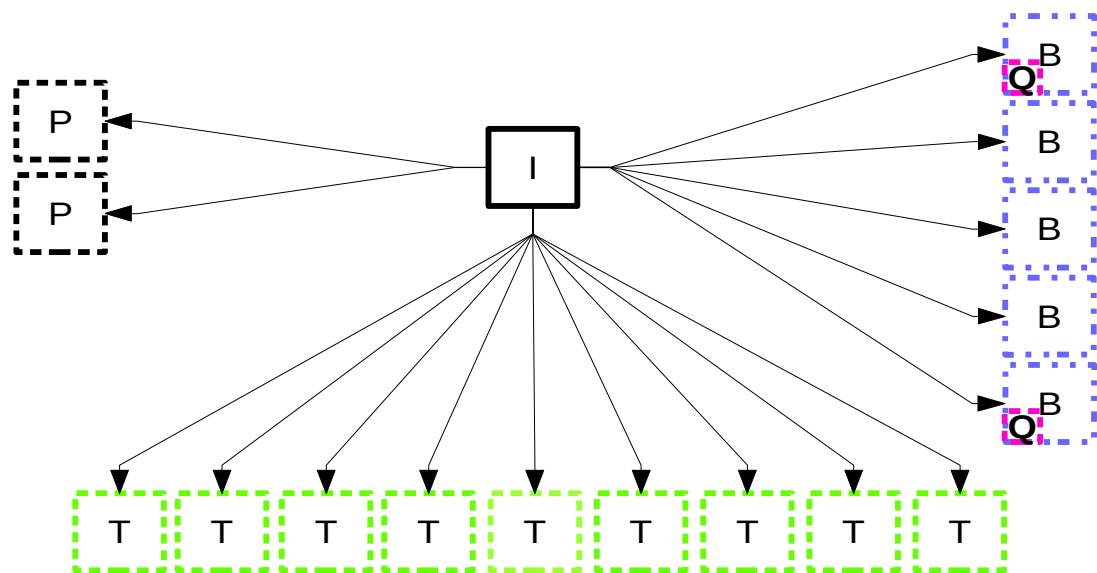


# Processing sequence

Contributions  
Knowledge-driven approach



Hypotheses of panels, balloons and text lines

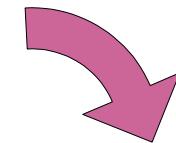


# Processing sequence

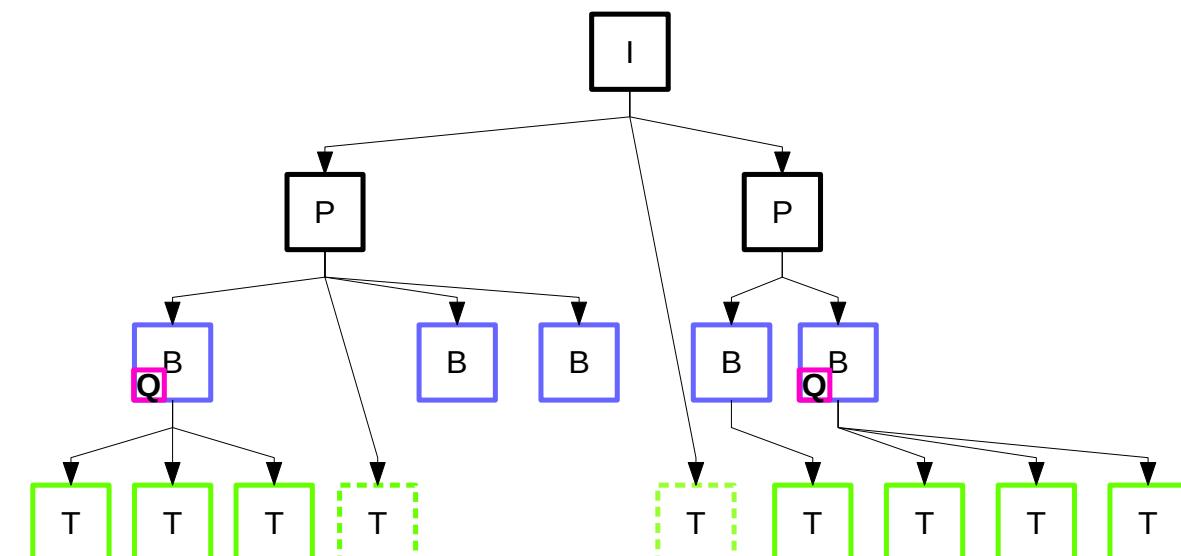
Contributions  
Knowledge-driven approach



Hypotheses of  
panels, balloons  
and text lines

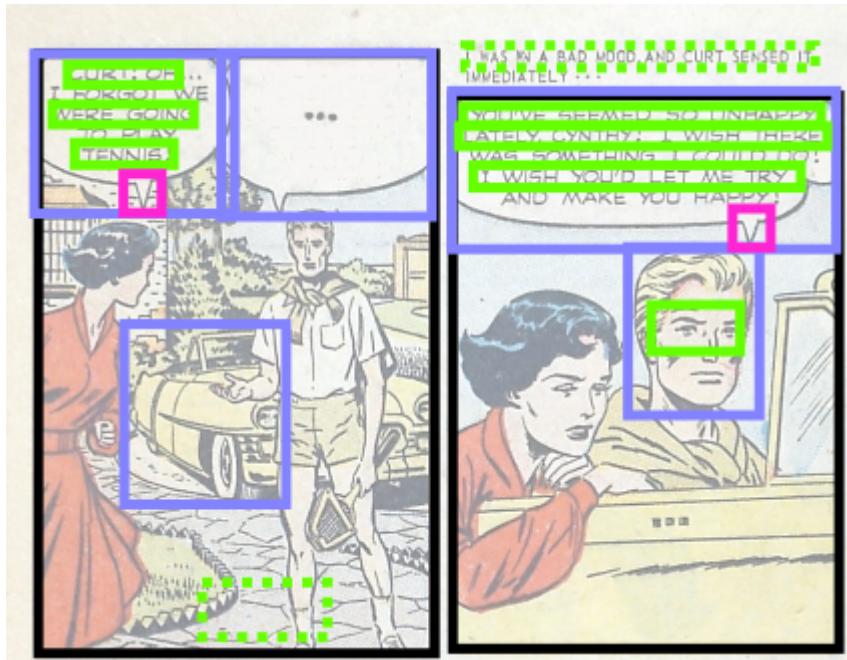


Validation of the  
hypotheses

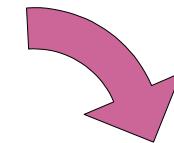


# Processing sequence

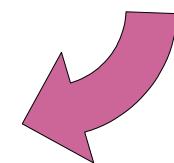
Contributions  
Knowledge-driven approach



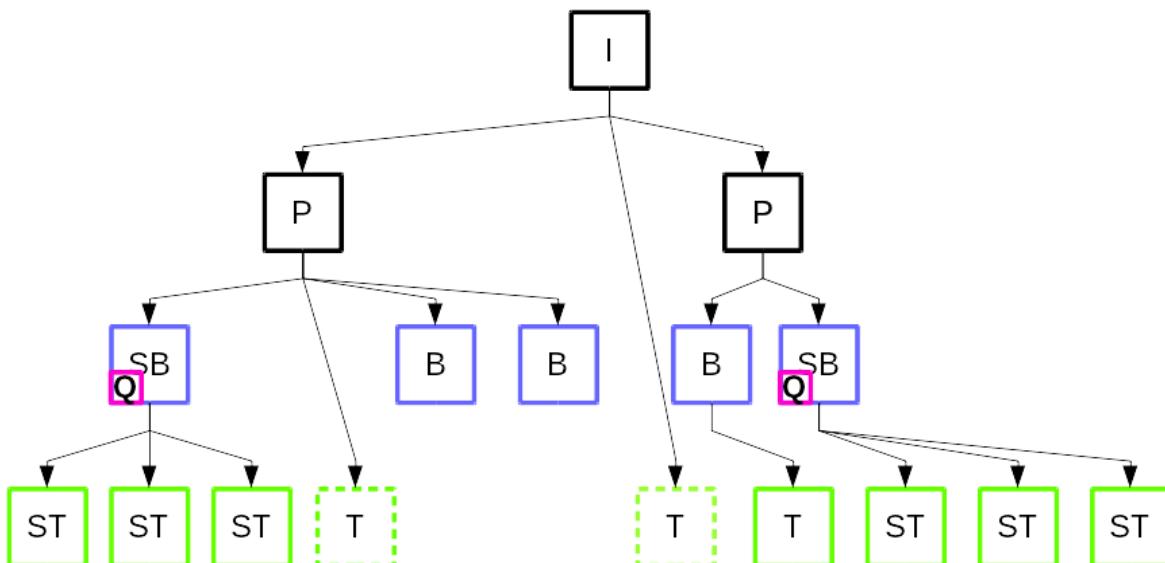
Hypotheses of  
panels, balloons  
and text lines



Validation of the  
hypotheses

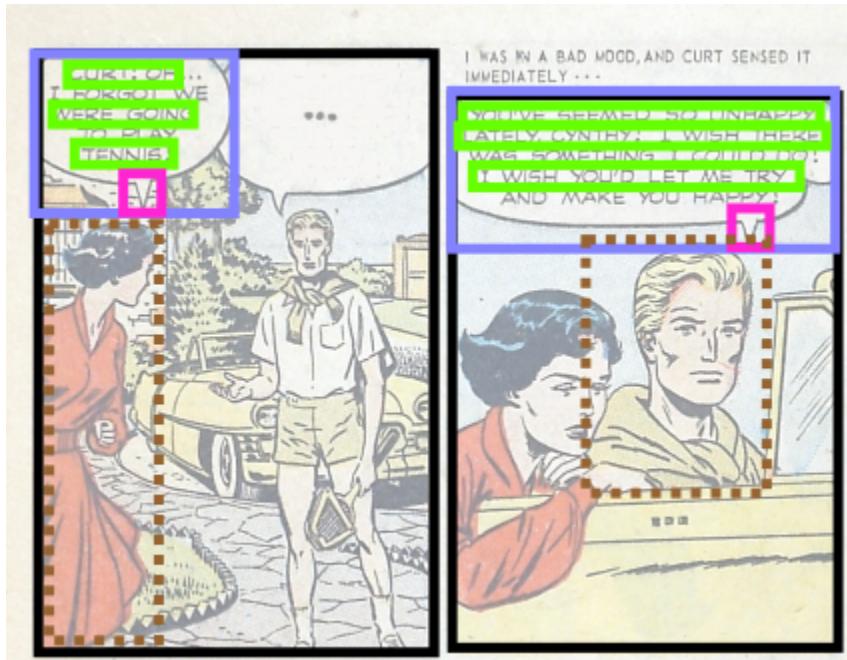


Inferences of  
specific types



# Processing sequence

Contributions  
Knowledge-driven approach



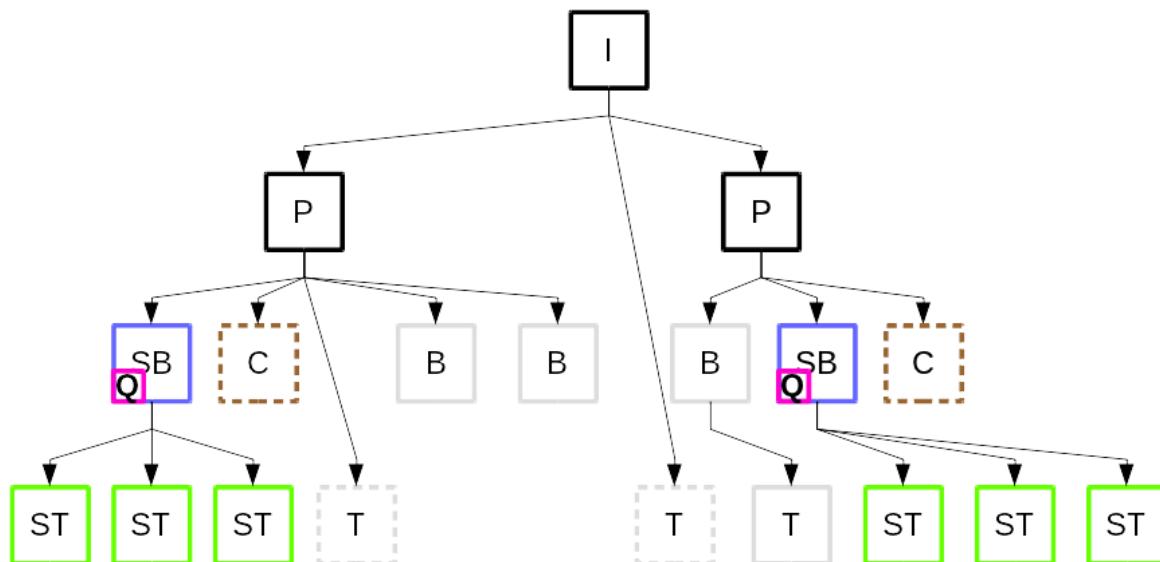
Hypotheses of  
comic characters



Validation of the  
hypotheses

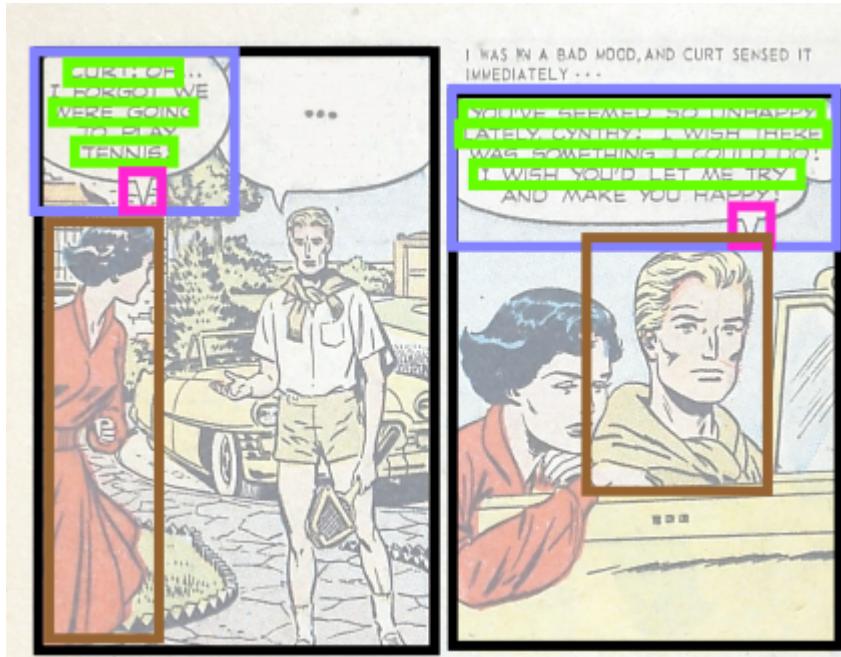


Inferences of  
specific types

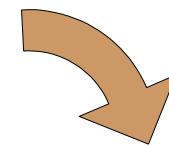


# Processing sequence

Contributions  
Knowledge-driven approach



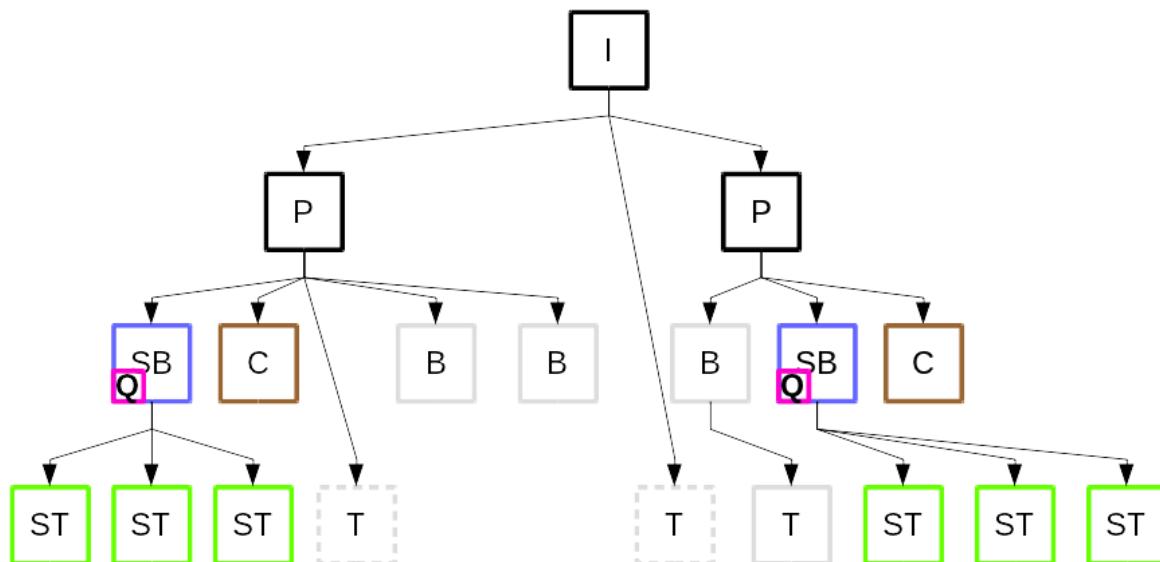
Hypotheses of comic characters



Validation of the hypotheses

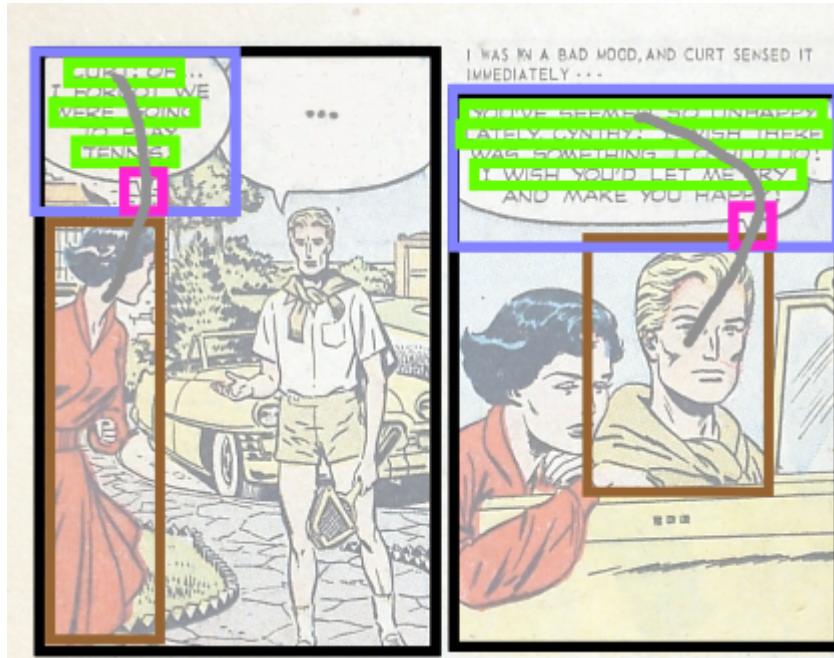


Inferences of specific types

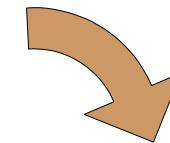


# Processing sequence

Contributions  
Knowledge-driven approach

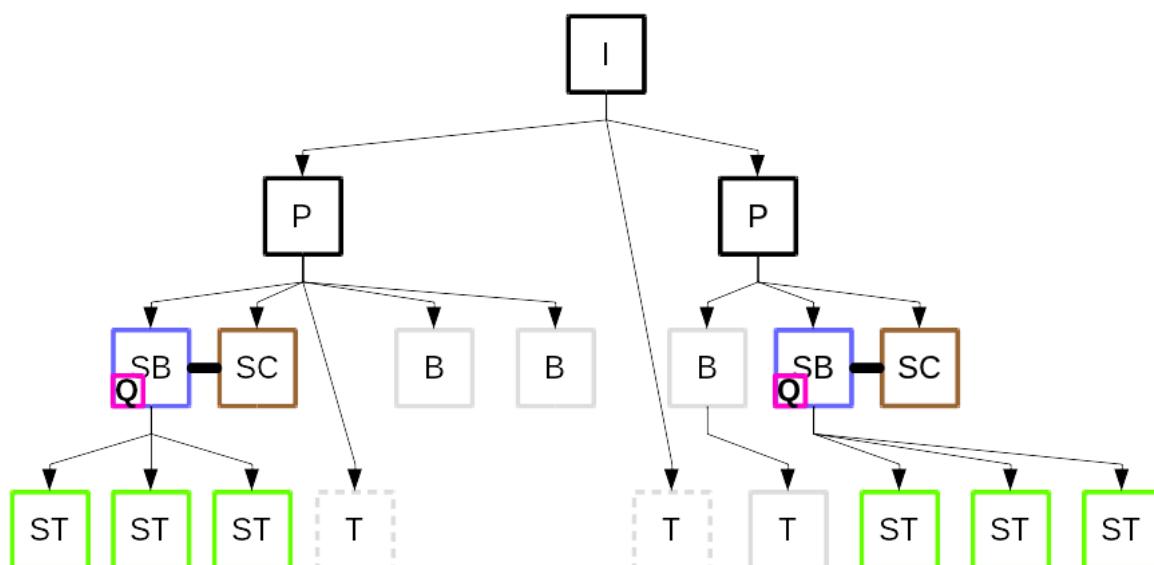
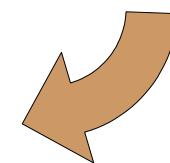


Hypotheses of  
comic characters



Validation of the  
hypotheses

Inferences of  
specific types  
+ semantic links



- Dataset and ground truth
- Evaluations
- Conclusions



Lettering. Image credits: Le cycle des bulles,  
Christophe Rigaud, 2012

# Dataset and ground truth

- Absence of public dataset
- Creation of heterogeneous dataset
  - 100 mixed pages from 20 albums
  - Franco-Belgium “bandes dessinées”, American comics and Japanese manga
  - From 1905 to 2012, paper and webcomics
  - Rights holder permissions agreement
- Online: <http://ebdtheque.univ-lr.fr>

# Experiments

## Bibliographic annotations



**PAGE** (100)  
**Collection:** Chilling Tales  
**Album:** 17 Geo  
**Editor:** Youthful Magazines  
**Drawer:** Matt Fox  
**Writer:** Matt Fox  
**Language:** English  
**Page number:** 16  
**Release date:** 1953

## Visual and semantic annotations



**PANEL** (850)  
**Rank:** 1  
**BALLOON** (1092)  
**Rank:** 2  
**Shape:** Oval  
**Tail direction:** South-West  
**TEXT LINE** (4691)  
**Text:** « STARK RAVING »  
**CHARACTER** (1550)  
**LinkedToBalloon:** 2

# Evaluations

# Experiments

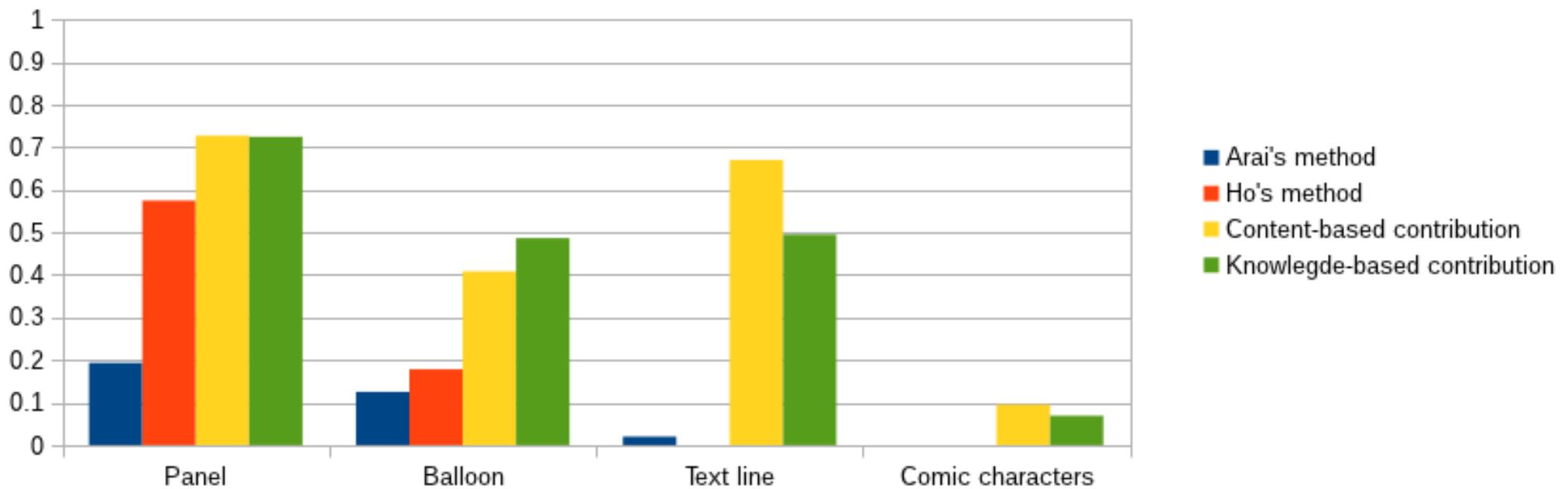
$$a_0 = \frac{\text{area}(B_p \cup B_{gt})}{\text{area}(B_p \cap B_{gt})}$$

$B_p$  = predicted region

$B_{gt}$  = ground truth region

$B_p$  valid if  $a_0 > 0.5$

Element localisation results (F-score)



- Global conclusions
- Global perspectives
- Publications



Lettering. Image credits: Le cycle des bulles,  
Christophe Rigaud, 2012

# Global conclusions

# Conclusion

- Reached objectives
  - Comics **image segmentation** and understanding
  - **TODO: revisit objectives/challenges from intro**
- Contributions of the thesis
  - Comic book content **extraction methods improvement**
  - **First approaches** for tail detection, balloon classification and speaker extraction
  - Public **dataset** and ground truth
- Research impacts (**TODO: replace by numbers and move to next page?**)
  - **L3i** is now a **main actor** of comic book analysis in Europe
  - New Ph.D. **thesis** started in 2013 (Nam Le Thanh)
  - **Dataset** used by international peers (**TODO: list them all?**)
  - **National projects** (PIA BigData Actialuna + LIP6, ANR EXPION 2015)
  - **International project** on manga analysis (PHC-SAKURA with Japan)

# Global perspectives

## Conclusion

- Content extraction
  - Panels: implicit, overlapping and connected
  - Text: recognition
  - Balloon: implicit extraction and evaluation
  - Comic characters: non-speaking and identification
- Content understanding
  - Situation retrieval
  - Object interaction retrieval
  - Label elements from text analysis
- Dataset
  - Increase the number of pages
  - Panel view angle and situation
  - Multi-part comic character segmentation
  - Comic character names and roles

# Publications

- TODO

# Conclusion

# References

# Conclusion

- [Chung07] ChungHo Chan, Howard Leung, and Taku Komura. Automatic panel extraction of color comic images. In HoraceH.-S. Ip, OscarC. Au, Howard Leung, Ming-Ting Sun, Wei-Ying Ma, and Shi-Min Hu, editors, *Advances in Multimedia*
- [Eunjung07] Eunjung Han, Kirak Kim, HwangKyu Yang, and Keechul Jung. Frame segmentation used mlp-based x-y recursive for mobile cartoon content. In *Proceedings of the 12th international conference on Human-computer interaction: intelligent multimodal interaction environments, HCI'07*, pages 872–881, Berlin, Heidelberg, 2007. Springer-Verlag
- [Tanaka07] Takamasa Tanaka, Kenji Shoji, Fubito Toyama, and Juichi Miyamichi. Layout analysis of tree-structured scene frames in comic images. In *IJCAI'07*, pages 2885–2890, 2007
- [Arai10] Kohei Arai and Herman Tolle. Method for automatic e-comic scene frame extraction for reading comic on mobile devices. In *Seventh International Conference on Information Technology: New Generations, ITNG '10*, pages 370–375, Washington, DC, USA, 2010. IEEE Computer Society
- [Pang14] Xufang Pang, Ying Cao, Rynson W.H. Lau, and Antoni B. Chan. A robust panel extraction method for manga. In *Proceedings of the ACM International Conference on Multimedia, MM '14*, pages 1125–1128, New York, NY, USA, 2014

# References

# Conclusion

- [Stommel12] Martin Stommel, Lena I Merhej, and Marion G Müller. Segmentation-free detection of comic panels. In Computer Vision and Graphics, pages 633–640. Springer, 2012
- [Li14a] Luyuan Li, Yongtao Wang, Zhi Tang, and Liangcai Gao. Automatic comic page segmentation based on polygon detection. *Multimedia Tools Applications*, 69(1):171–197, 2014
- [Li14b] Luyuan Li, Yongtao Wang, Zhi Tang, Xiaoqing Lu, and Liangcai Gao. Unsupervised speech text localization in comic images. In Proceedings of International Conference on Document Analysis and Recognition (ICDAR), pages 1190–1194, Aug 2013
- [Ponsard12] Christophe Ponsard, Ravi Ramdoyal, and Daniel Dziamski. An ocr-enabled digital comic books viewer. In Computers Helping People with Special Needs, pages 471–478. Springer, 2012

Thank you + github + c-r

Conclusion

- Authors, publishers, CIBDI
- Founding: Communauté d'Agglomération de La Rochelle
- Time for demo on easy case with comic character ROI computation?



# Complementary information

# History of comics art

- Pre-history: **painting of animals** and hunters in **caves** [Marx, 2007]
- 1846: **Rodolphe Töpffer**, the inventor of the “**bandes dessinées**”
- 1930s: magazine-style **comic books** production in the **US**
- 1950s: massive production of **manga** in **Japan** (Osamu Tezuka)
- 1971: the term of **ninth art** is attributed to comics art (Francis Lacassin)
- 1996: explosion of the **Internet bubble** and **webcomics**
- 2007: adaptation to **social media sites** and **mobile devices**



Pre-history and ancient Egypt



Rodolphe Töpffer, Histoire de Monsieur Cryptogame (1830)



Ted McCall, Robin Hood And Company (1946)



Tezuka Osamu, Manga Classroom (1953)



Marion Montaigne, Tu mourras moins bête (2013)

# GT validation

# Knowledge-driven analysis detail

- Comic character region refinement

# Production to interpretation

Background

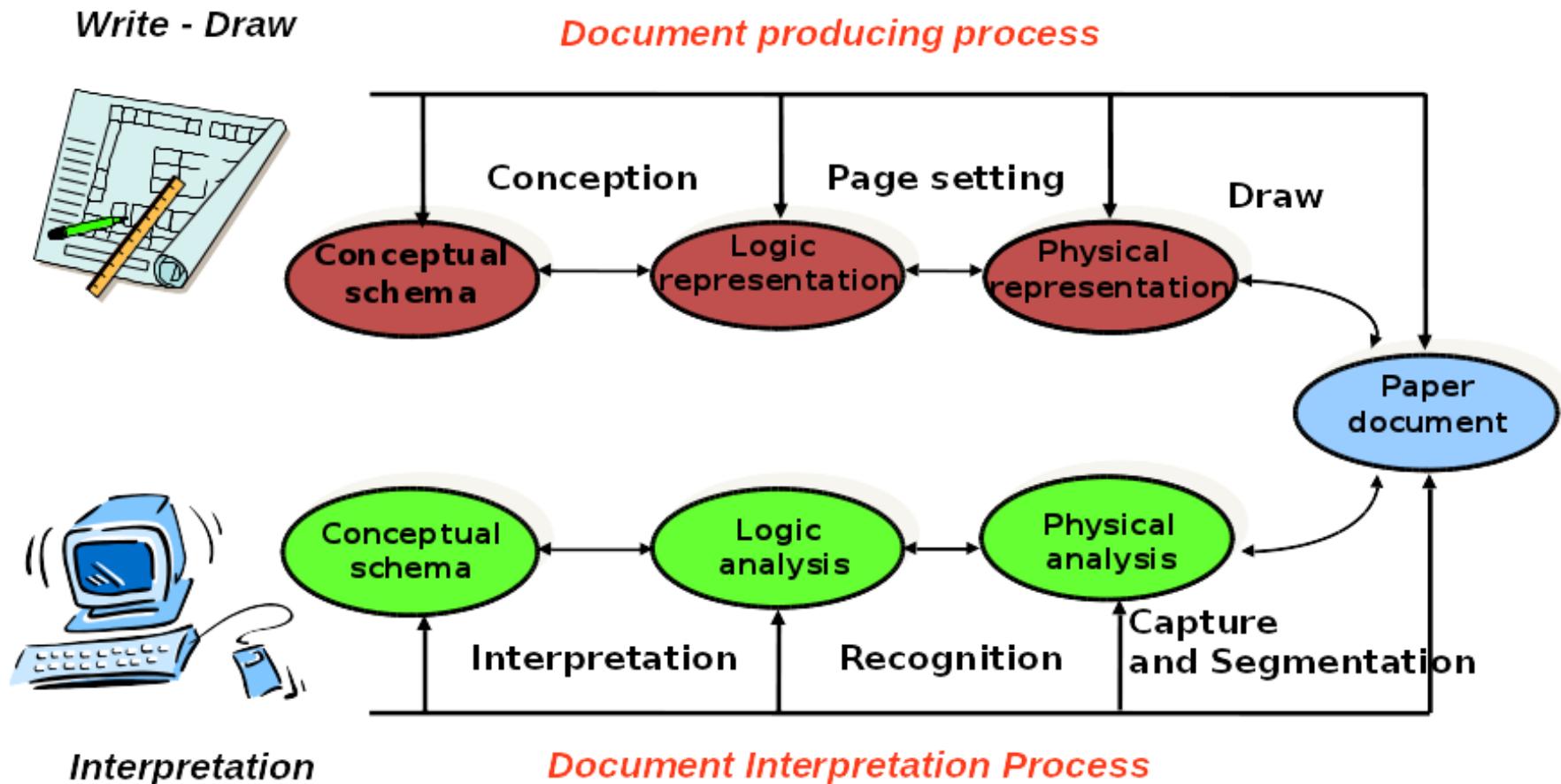


Image source: Handbook of Document Image Processing and Recognition. Springer, 2014

# Background



Thinking about the scenario. Image credits:  
Wissam Shekhani, 2010