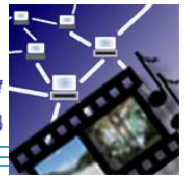

Compound Figure Separation Combining Edge and Band Separator Detection

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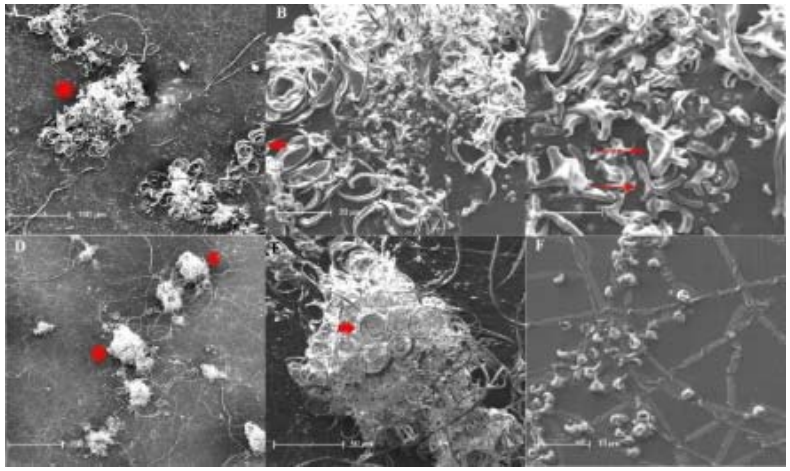
Oge Marques, FAU, Boca Raton, FL, USA

FAU
FLORIDA ATLANTIC UNIVERSITY

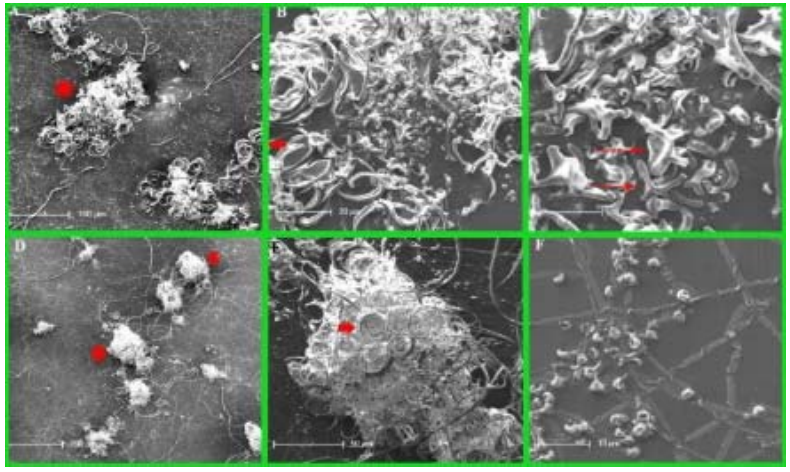
January 5, 2016
MMM 2016

PROBLEM

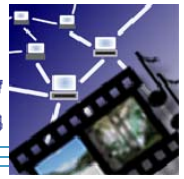


Compound image in scientific article

Compound figure separation (CFS) – automatic!



segmented into subfigures

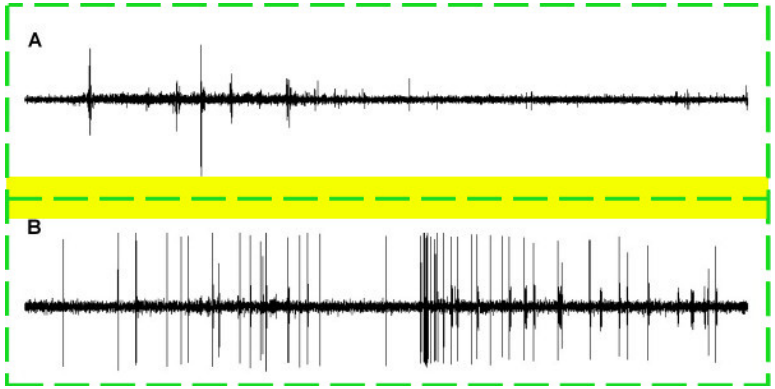


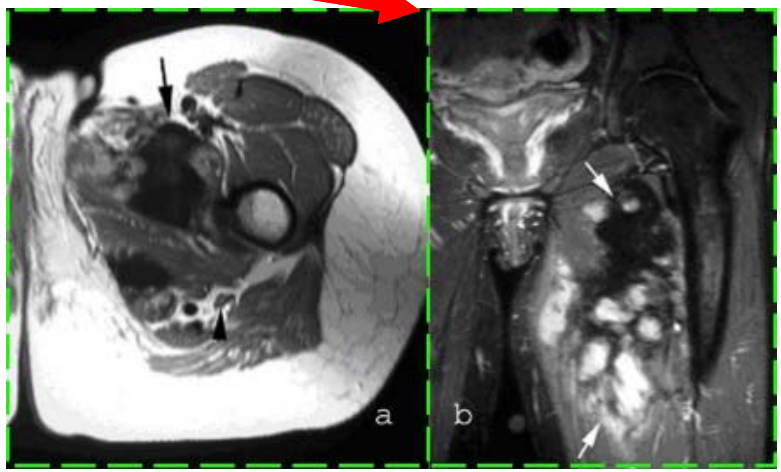
MOTIVATION

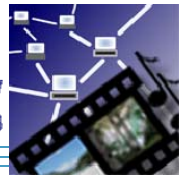
- Biomedical literature:
  - 40%-60% of figures in articles are compound
  - infeasible to separate subfigures manually
- Compound images hinder
  - Content-based analysis
  - Content-based indexing for retrieval
- CFS recognized as research problem recently
  - research fostered by ImageCLEF CFS tasks in 2013 and 2015 (biomedical domain)

KNOWN APPROACHES

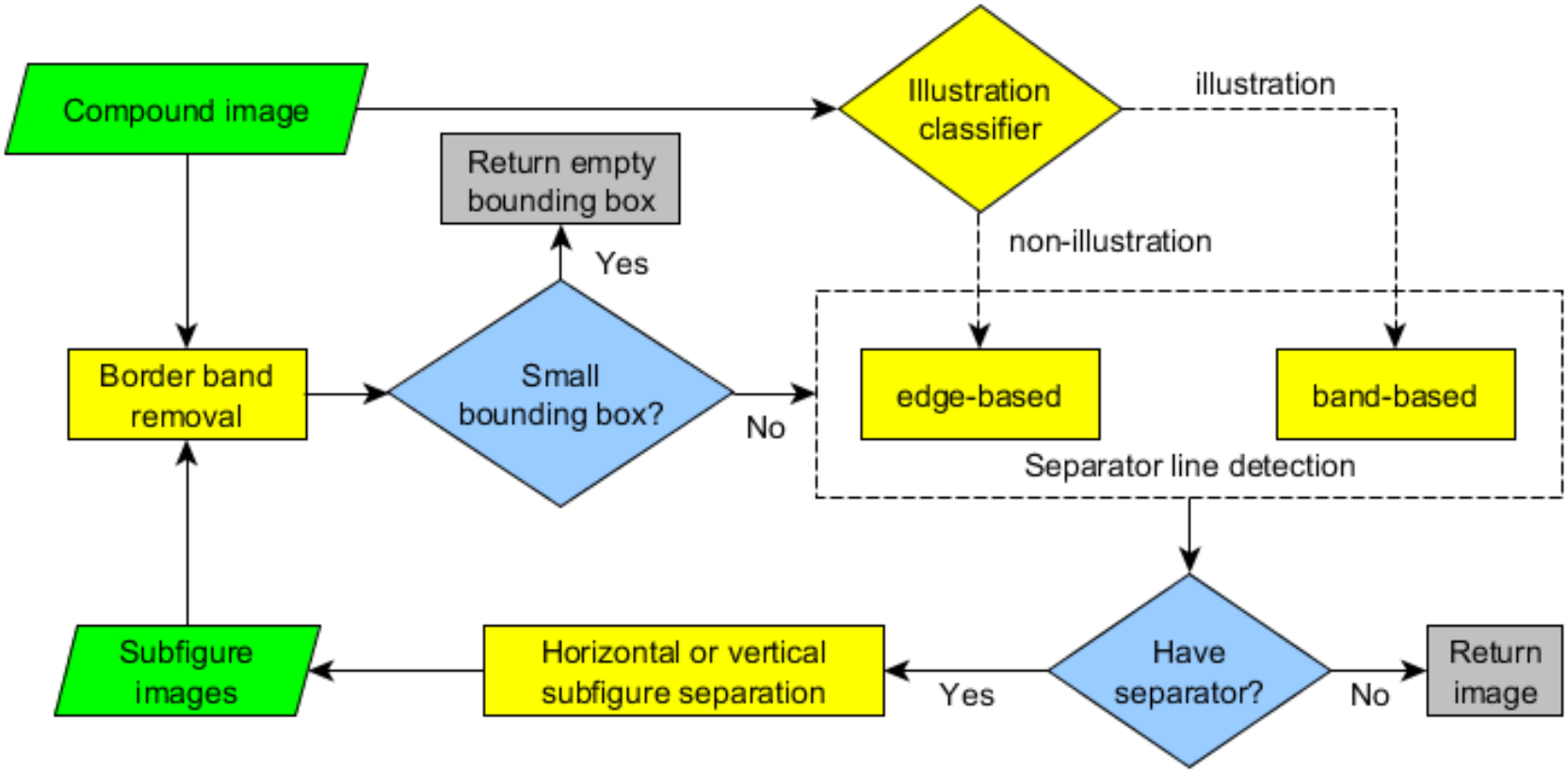
- Most approaches detect separator bands
- Very few detect separator edges
- No automatic combination yet
- We propose automatic selection of edge-based / band-based separation

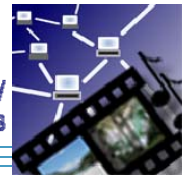






PROPOSED APPROACH





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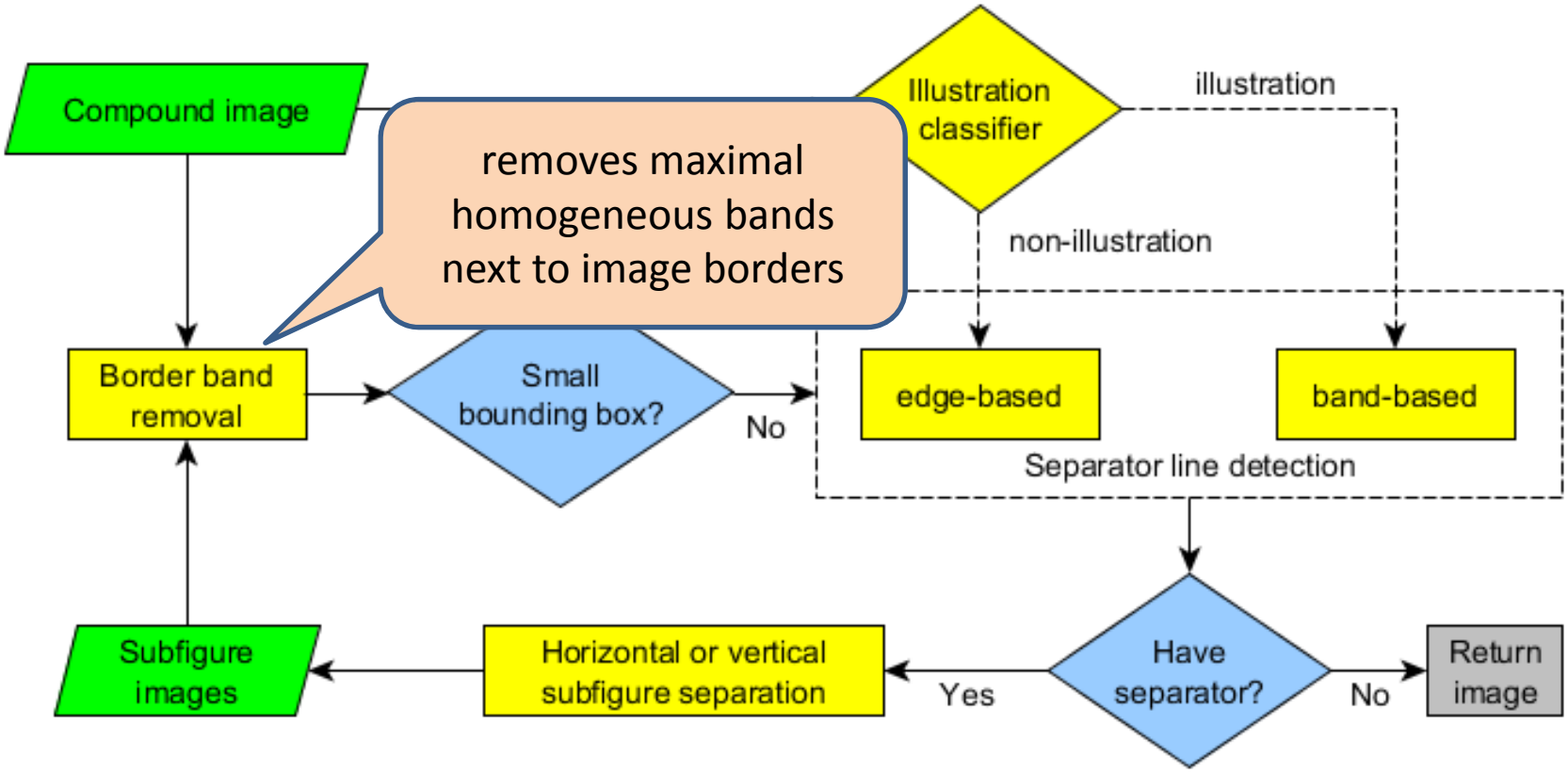

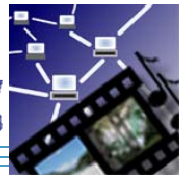

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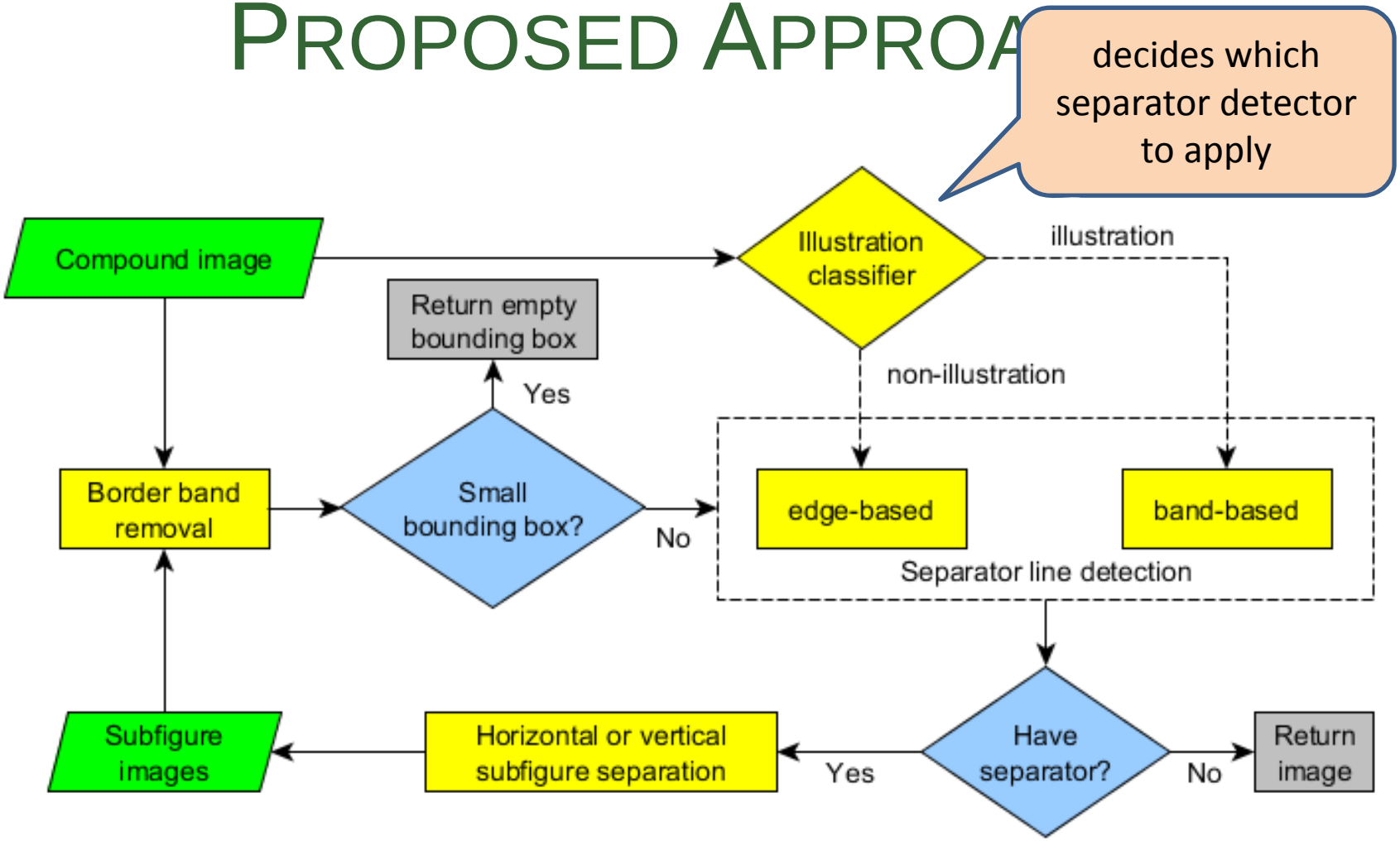

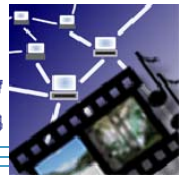

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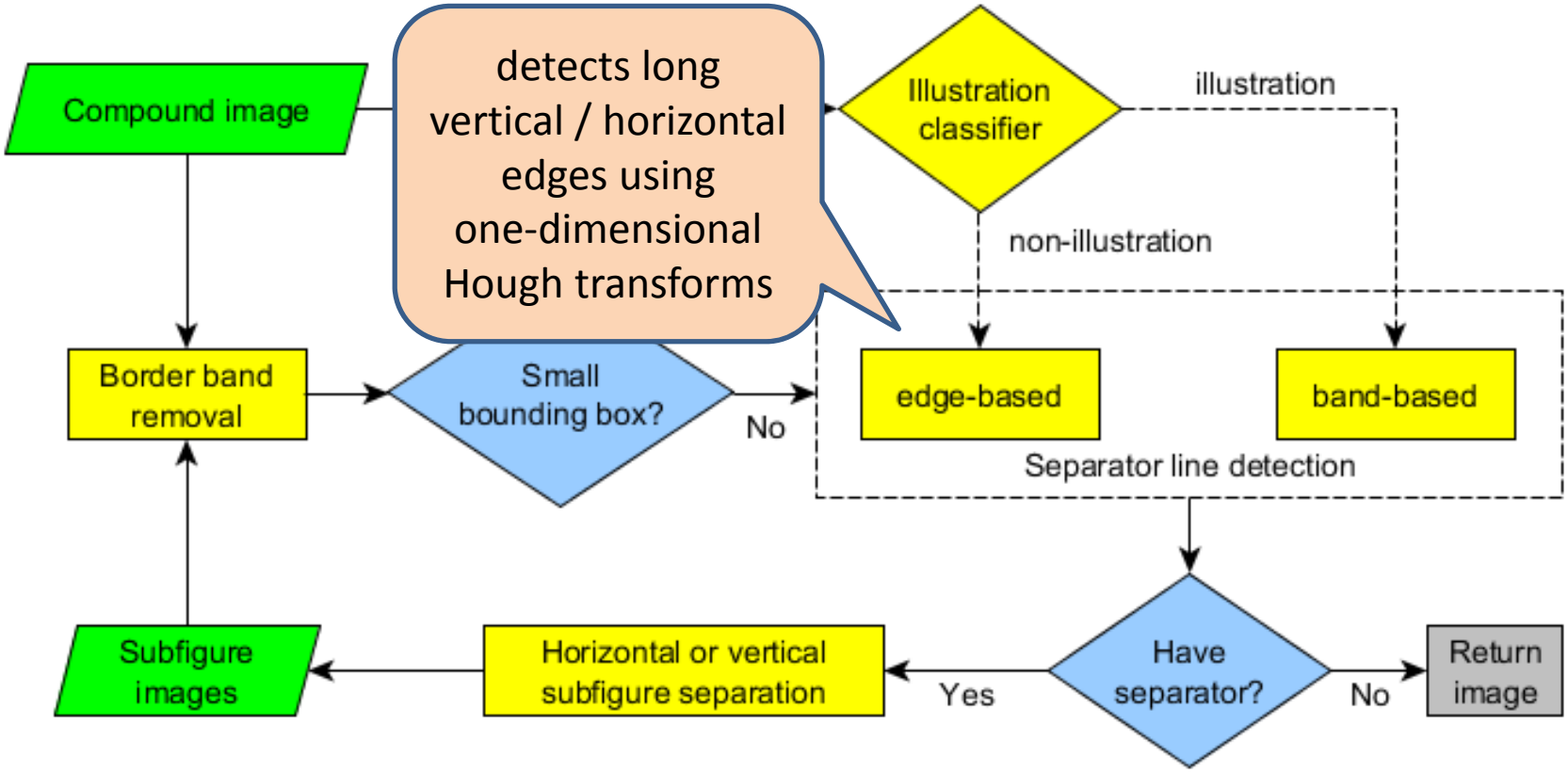

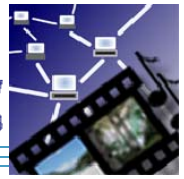

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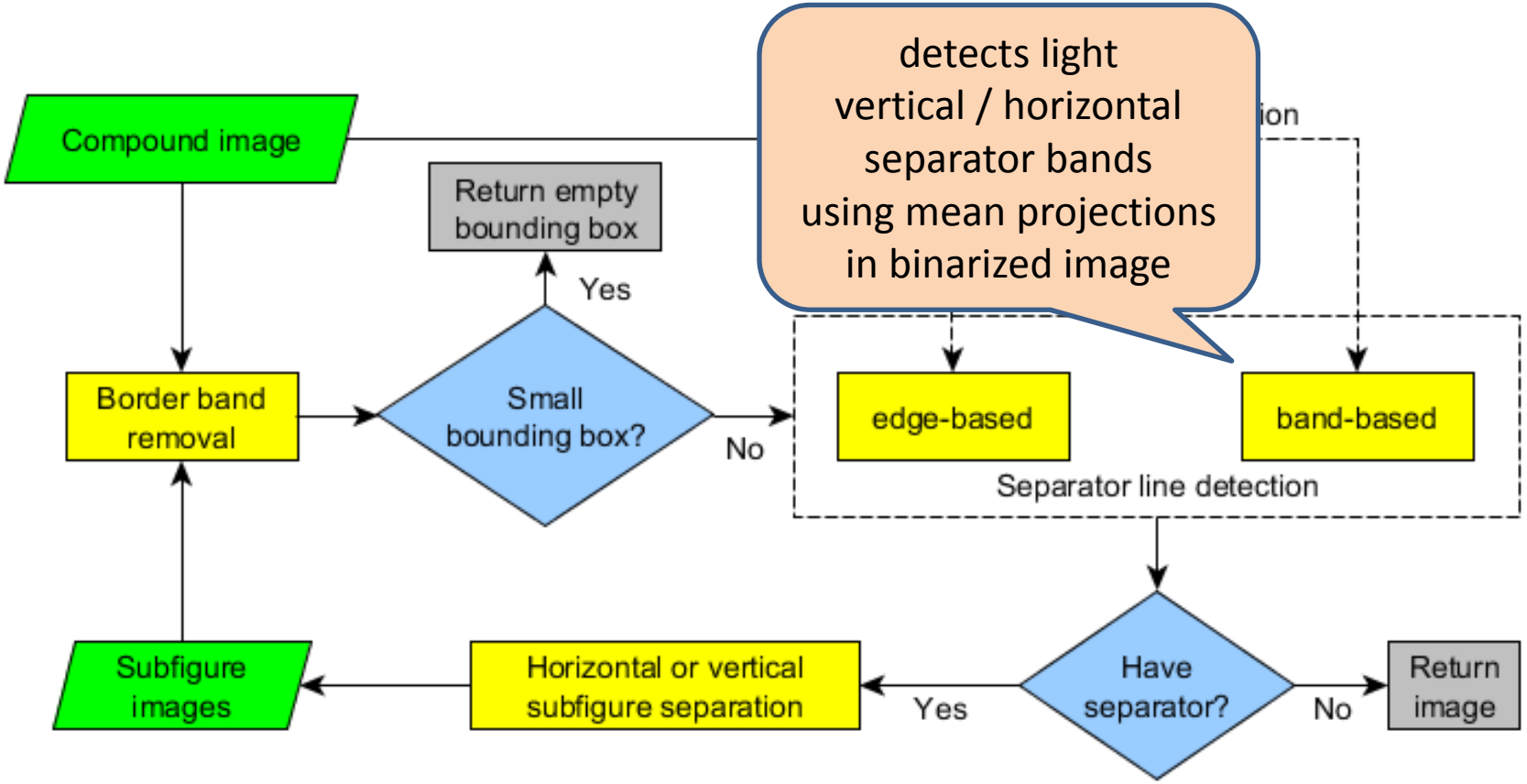

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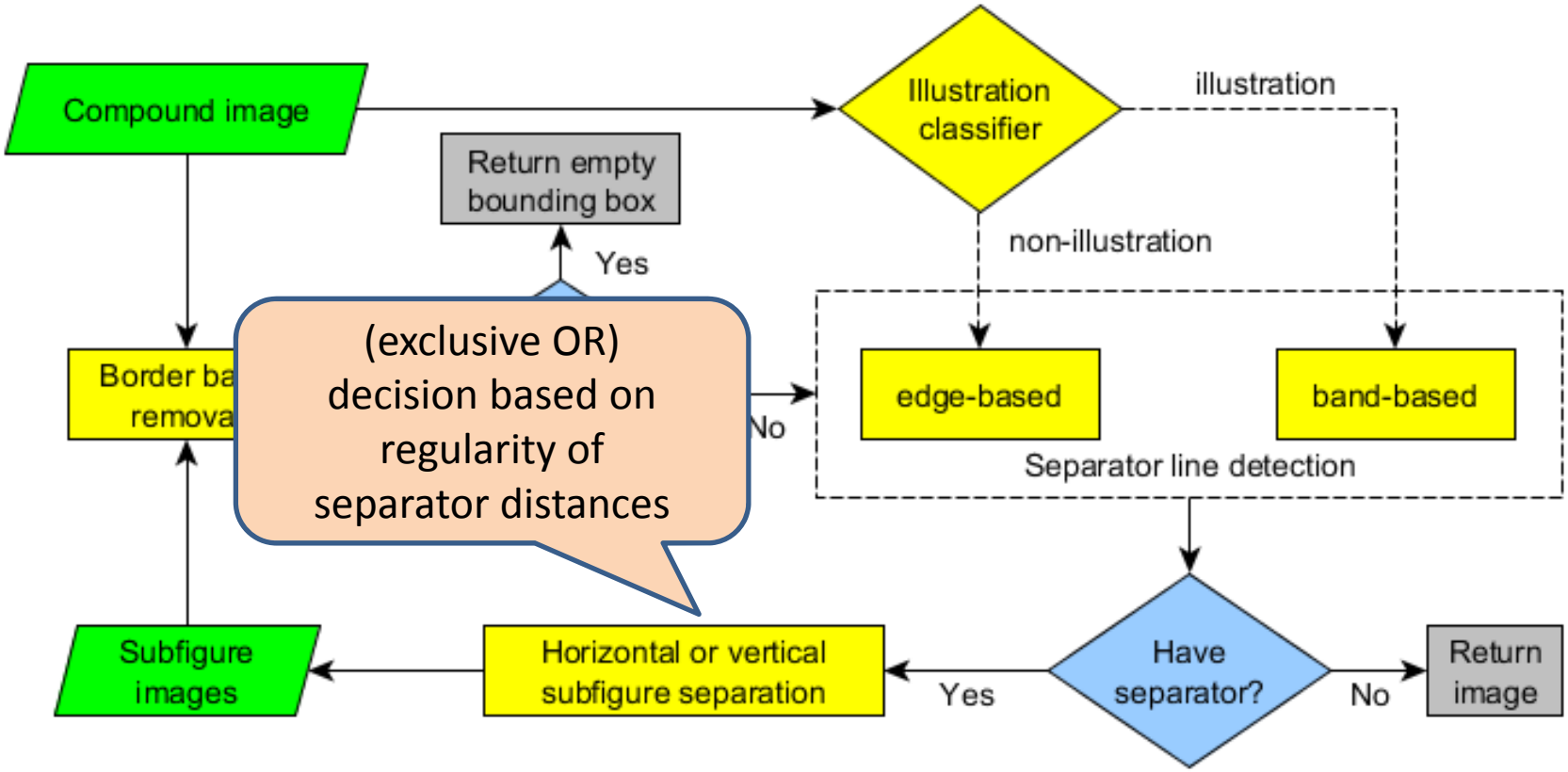

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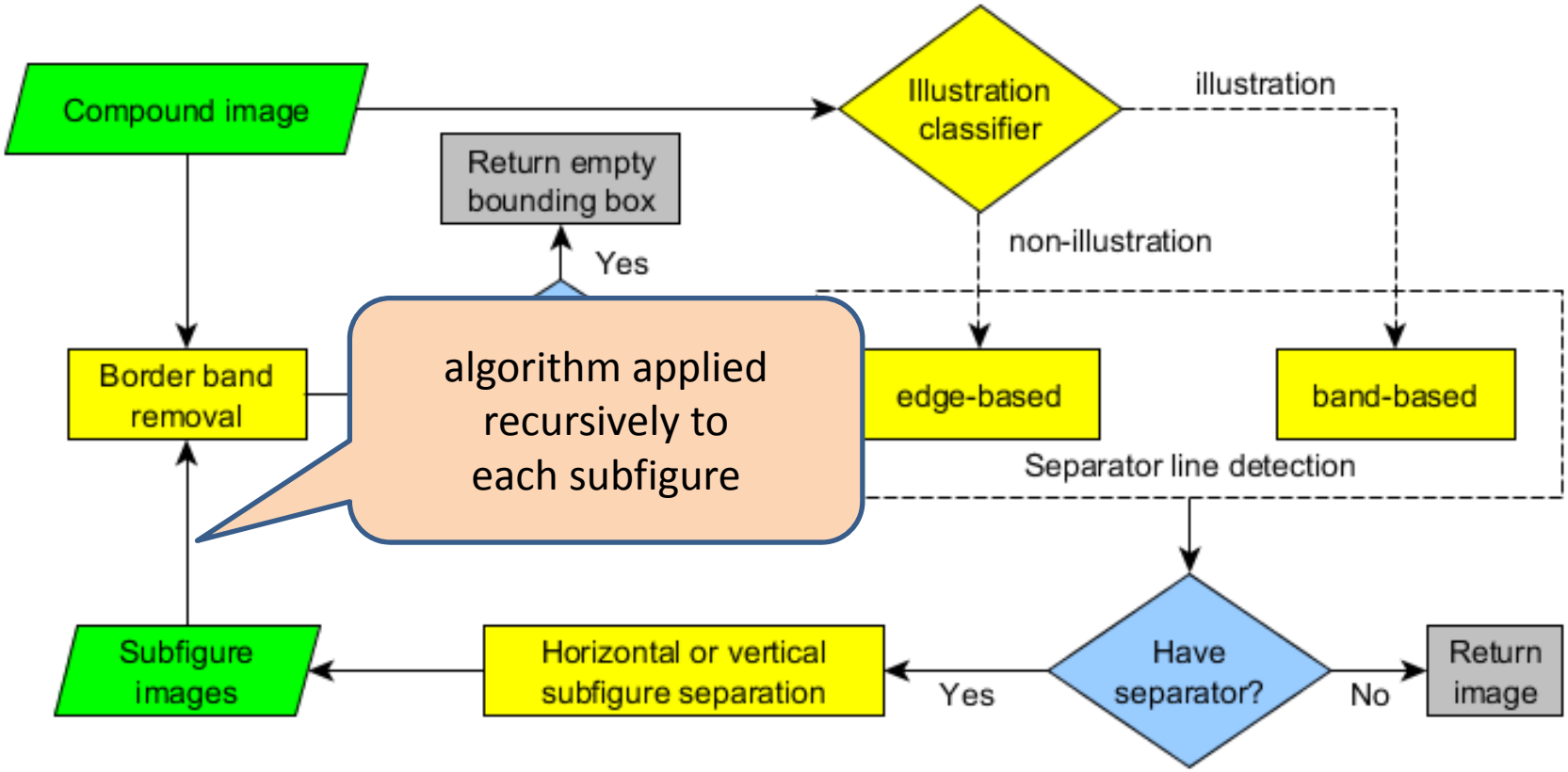
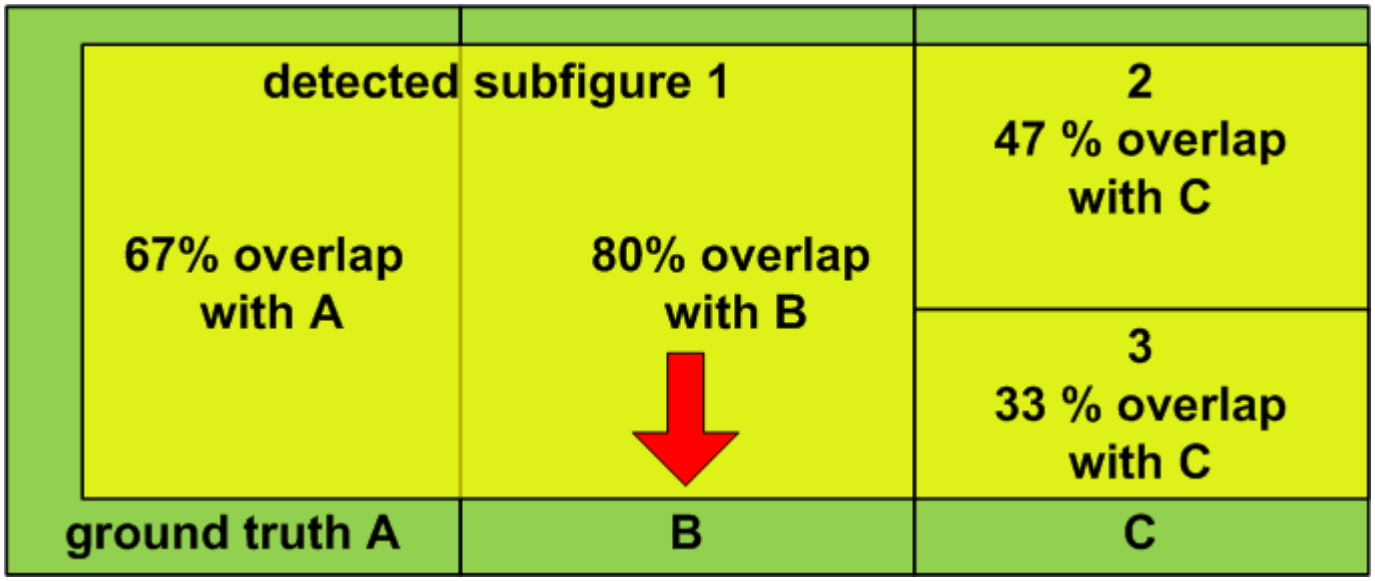


DATASET 1 FOR EVALUATION

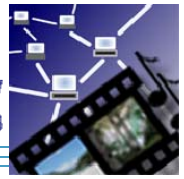
- ImageCLEF 2015 test dataset:
  - 3,381 compound figures from biomedical journals containing 12,789 ground-truth subfigures
- Accuracy is defined per compound figure:
  - N_D – number of detected subfigures
  - N_G – number of ground-truth subfigures
  - True positives TP: 1-to-1 mapping from detected to ground-truth subfigures (maximal overlap ≥ 66%)
  - Accuracy = TP / max(N_D, N_G)
- Report mean accuracy on test dataset

ACCURACY ON DATASET 1

- N_D – number of detected subfigures
- N_G – number of ground-truth subfigures
- True positives TP: 1-to-1 mapping from detected to ground-truth subfigures (maximal overlap ≥ 66%)
- Accuracy = TP / max(N_D, N_G)



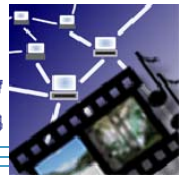
$N_D = N_G = 3$
TP = 1
Accuracy = 1/3



RESULTS ON DATASET 1

Method	Classifier / Features	Band-based %	Accuracy %
Proposed	None	0	58.0
Proposed	None	100	82.2
Proposed	SVM / simple11	60.3	83.5
Proposed	LogReg / simple11	74.1	**84.9**
NLM [7]	Manual	95.7	84.6

- LogReg: logistic regression, predicts class probability
  - decision threshold optimized on CFS training set
- simple11: 11-dimensional global image feature
  - entropy, mean intensity
  - 9 quantiles of intensity distribution



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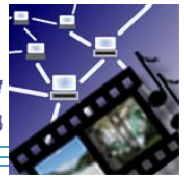
- Proposed approach outperforms
  - proposed variants without illustration classifier
  - semi-automatic approach of U.S. National Library of Medicine (NLM, best submission at ImageCLEF 2015)



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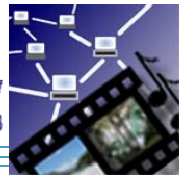
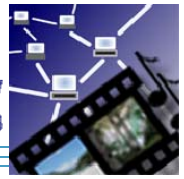
NLM [7]	Manual	95.7	84.6

- Dataset is “biased” towards separator bands
  - NLM’s manual classification identified 96% band-separated compound figures
  - explains why our band-based-only variant achieves good performance



Dataset 2 for Evaluation

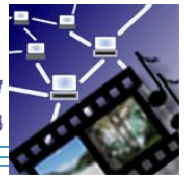
- NLM dataset [1]:
  - 389 compound figures from biomedical domain containing 1,754 ground-truth subfigures
- Stronger criterion for true positive subfigures:
  - ≥ 75% overlap with a single ground-truth subfigure
  - < 5% overlap with all other ground-truth subfigures
- Precision, recall and F_1 measure
  - calculated from total numbers of **detected**, **true positive** and **ground-truth** subfigures on entire test dataset



RESULTS ON DATASET 2

Method	detected	TP	Precision %	Recall %	F1 %
Proposed, SVM/simple11	1681	1392	82.8	79.4	81.1
Proposed, LogReg/simple11	1646	1407	85.5	**80.2**	**82.8**
NLM [1]	1482	1276	**86.1**	72.3	78.6

- Indicate generalization capability:
  - used same parameter settings as with dataset 1
  - relative performance consistent with previous results
- Band-based separator selection rate: 33%
  - substantial difference to dataset 1 (74%)



CONCLUSION AND FURTHER WORK

- Proposed compound figure separation approach:
  - uses a **supervised classifier** to select separator line detection method (band-based or edge-based)
    - classifier accuracy is not critical for CFS performance
    - optimizing classifier's decision on CFS training set helps
    - future work may include finding more discriminative features / better training sets
  - consistently **better than previously published results** on 2 datasets, using same parameter settings
  - may be **extended by other known useful techniques** (image markup removal, subfigure label recognition)