Automatic Line Segmentation and Ground-Truth Alignment of Handwritten Documents

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Introduction

To train recognition systems, we need **annotated (position and transcript) lines of text**

On the web, we can retrieve many **transcribed images without line positions** ⟶ we have to **map the transcript to the image**

In the litterature, line positions are assumed to be known or reliably obtained with automatic methods

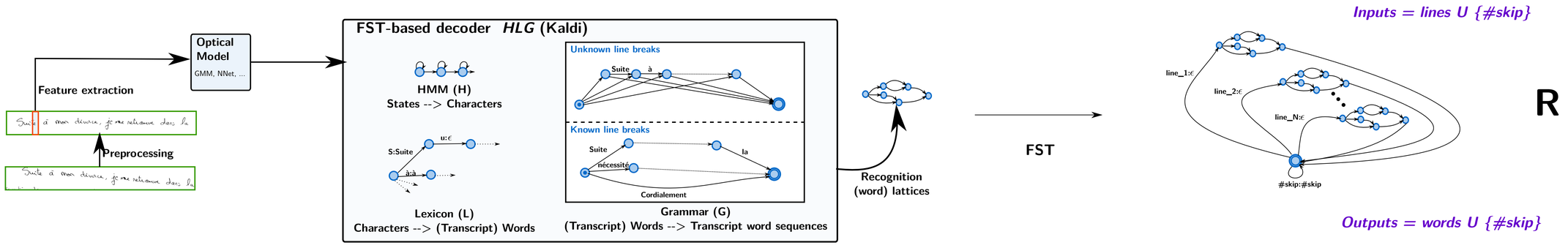
We propose a method able to ...

- ☆ consider **several segmentation hypotheses**
- ☆ **jointly find** the segmentation and transcript mapping
- ☆ **reject lines** in the segmentation, which content is not in the transcript
- ☆ perform the **mapping with a recognition system**, constrained by the transcript

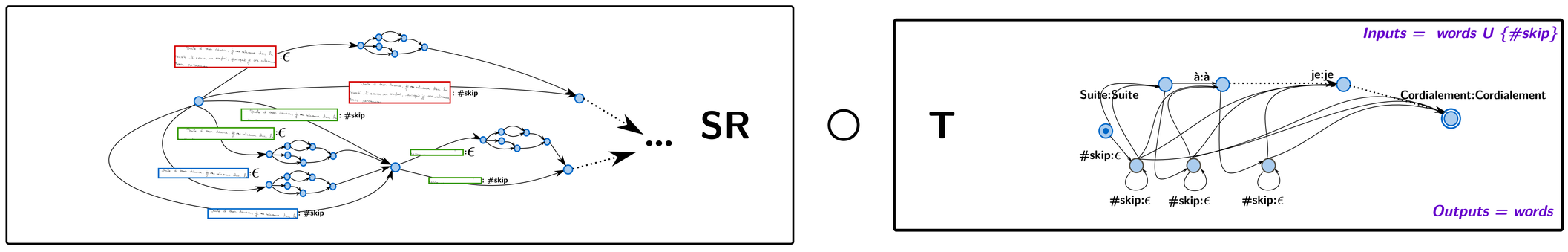
Method

Segmentation Hypotheses Transducer

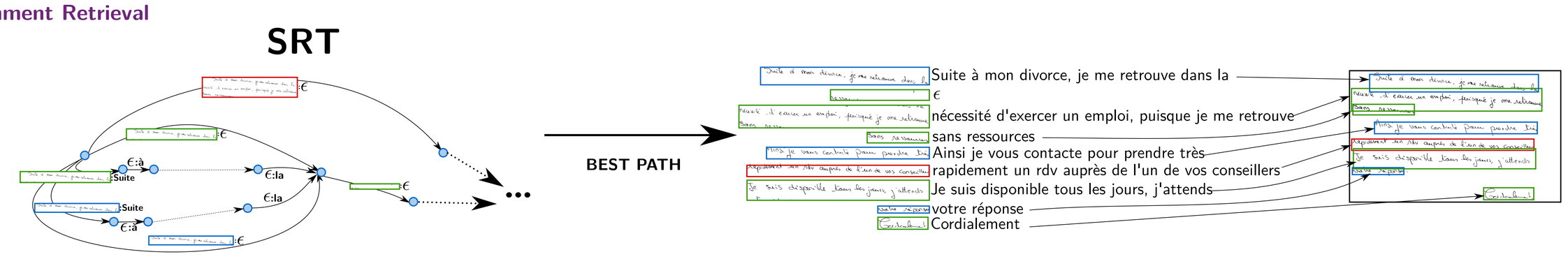
Recognition Hypotheses Transducer



Transcript Transducer



Alignment Retrieval



Results

Analysis

- ☆ To evaluate the method, we have to measure the quality of the **segmentation** and of the **mapping**
- ☆ We applied the method on public databases for which we know the line positions and transcript (Rimes, IAM)
- ☆ **Segmentation error = ZoneMap**

  ZoneMap aligns bounding boxes from a reference and an hypothesis in terms of *Matches, Misses, Merges, Splits and False Alarms*

  The error counts *black pixels that are missed or falsely included* in an hypothesis segmentation w.r.t the reference segmentation
- ☆ **Mapping error = Edit Distance**

  We use the bounding box matching found with ZoneMap

  For each configuration, we count the number of word subsitutions, deletions, and insertions

  (Note: misses -> deletions, false alarms -> insertions)

We evaluated the **different aspects** of the method

- ☆ Influence of mapping on segmentation quality
- ☆ Benefits of keeping multiple segmentation hypotheses
- ☆ Influence of the different constraints and benefits of knowing line breaks in the transcript
- ☆ Influence of the recognition system

	Seg.Err.	Map.Err.
Shredding		
Segmentation only	1.56	-
Segmentation + Mapping	0.77	1.24
Rectangle Filtering		
Segmentation only	4.90	-
Segmentation + Mapping	6.03	4.48
Projection profile		
Segmentation only	1.56	-
Segmentation + Mapping	0.87	0.97
All three segmentations		
Segmentation only	282.38	-
Segmentation + Mapping	0.90	1.22
No transcript constraint (SR only)	0.75	3.28
No recognition order (no G in reco)	88.85	90.24
Known line break symbols	0.82	0.22
Optical Model		
GMM	0.90	1.22
BLSTM-RNN	0.80	0.11
BLSTM-RNN (Rimes)	1.06	0.16

Results on IAM (dev)

A practical usage: creation of training material

For the **Maurdor competition**, we had :

- ☆ Annotated zones of text (either 1 or more lines)
- ☆ But **no line position** for multi-line zones
- ☆ However, the transcript contains line break symbols

Method

1 - Train an RNN on single line zones
2 - Use it to map the transcript of multi-line zones
3 - Train a new RNN with the new material and go back to **2**

RNN Training Material	# lines / % of max	WER
Single-line zones	7,310 / 63.0	54.7%
AutoSegMap (iteration 1)	10,570 / 91.1	43.8%
AutoSegMap (iteration 2)	10,925 / 94.1	**35.2%**

Limitations - Future Work

- ☆ The current segmentation FST can only handle simple layouts
  --> we need to be **able to cope with multi-columns, side notes, etc.** with a more elaborated graph
- ☆ The segmentation FST could be improved if the segmentation algorithm returned positions with **confidence scores**
- ☆ The recognition is very constrained, and allows to only recognize transcript words
  --> an **implementation of line rejection at this level** could be beneficial
- ☆ The method cannot cope with transcript errors, as in other publications
  --> it could be implemented in the FST

Conclusions

We implemented several trivial constraints derived from the knowledge of the transcript.

- ☆ the transcript order in the decoding graph enables a **quick recognition and is crucial for a good mapping** even with a recognition system which has not been adapted
- ☆ the transcript FST is important for a **mapping that is consistent at the document level** (i.e. the same part of the transcript is not mapped to several lines)
- ☆ finding a good mapping with this method **generally improves the segmentation** (less lines are falsely accepted, but some are wrongly discarded)
- ☆ keeping several segmentation hypotheses is not always better than the best segmentation, but **good since we do not know *a priori* which segmentation algorithm will be better**

We applied this method to retrieve more training material for recognition systems

- ☆ in the Maurdor evaluation, this accounted for a **35.6% relative improvement** and was crucial for winning the competition
- ☆ in other projects, this helped to quickly create annotated databases for handwriting recognition system training

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