Textbook-Informed Lecture Video Segmentation for Fine-Grained OER Reuse

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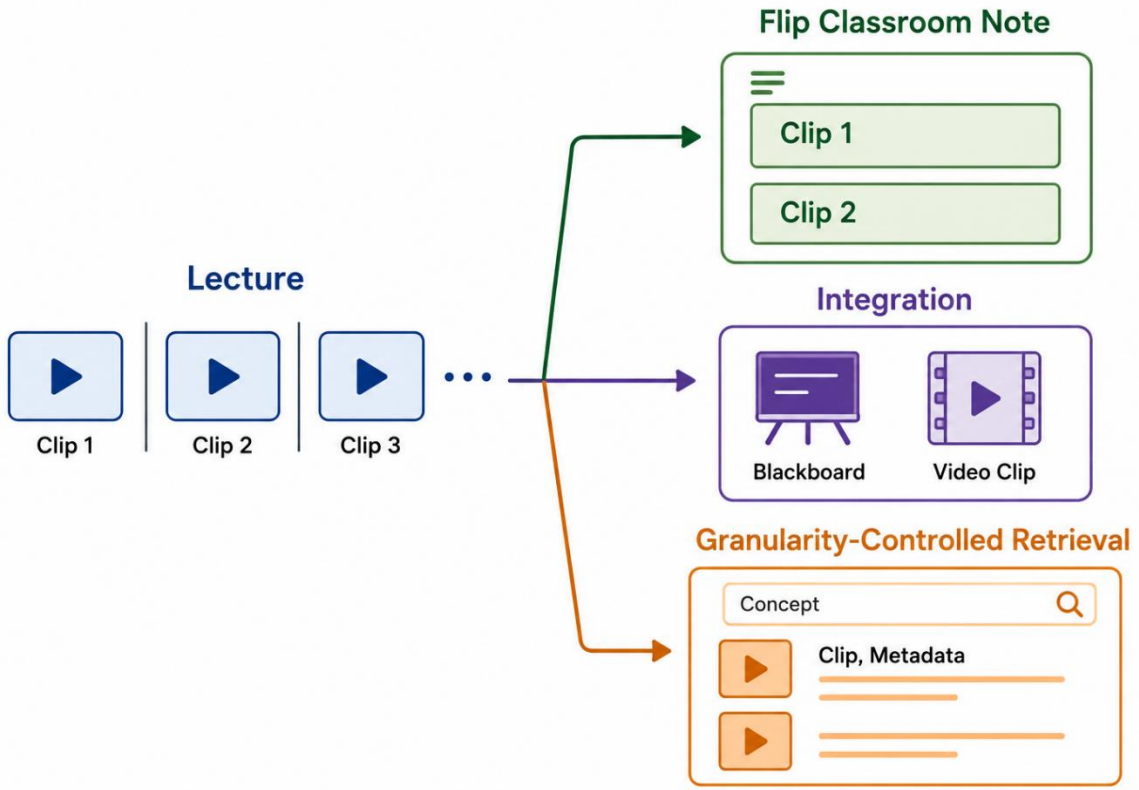
- Motivation
- Limitations of Existing Methods
- Proposed Aproach
- Future Directions

Motivation

This work is motivated by facilitating the reuse of lecture OER (Open Educational Resource).

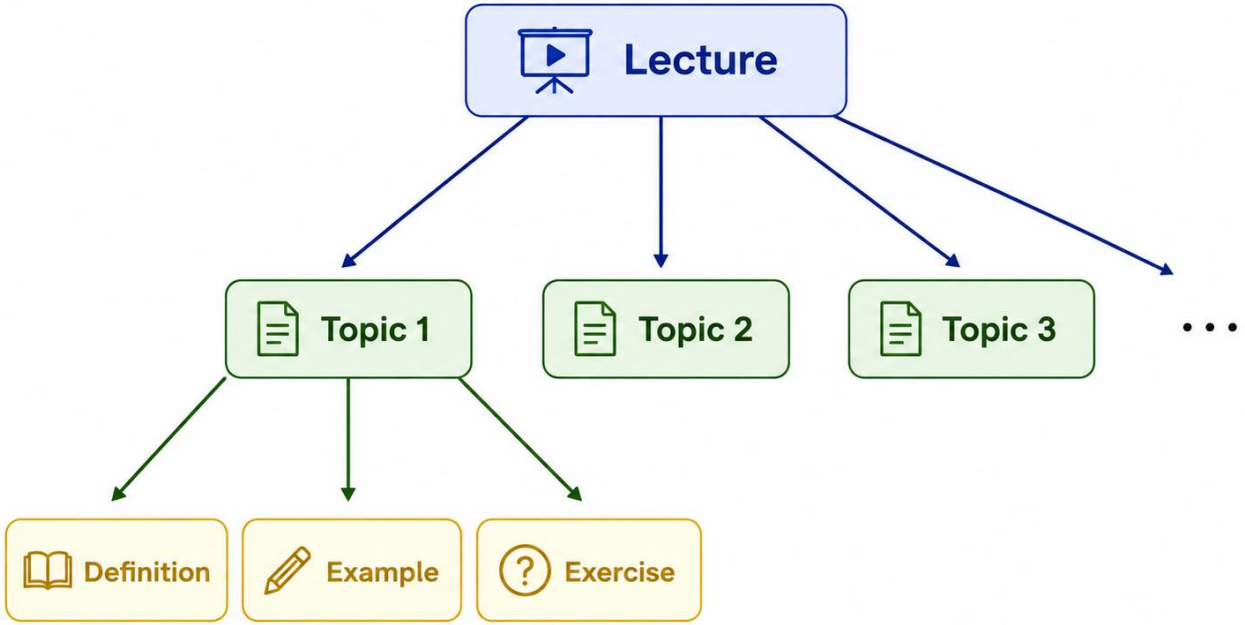
We focus on lecture segmentation field.



How segmentation enables lecture reuse

Hierarchical Nature of Lectures

To elaborate on specific topic, lecture is highly hierarchical.



Lecture Hierarchy

However, existing segmentation method is limited by such setup.

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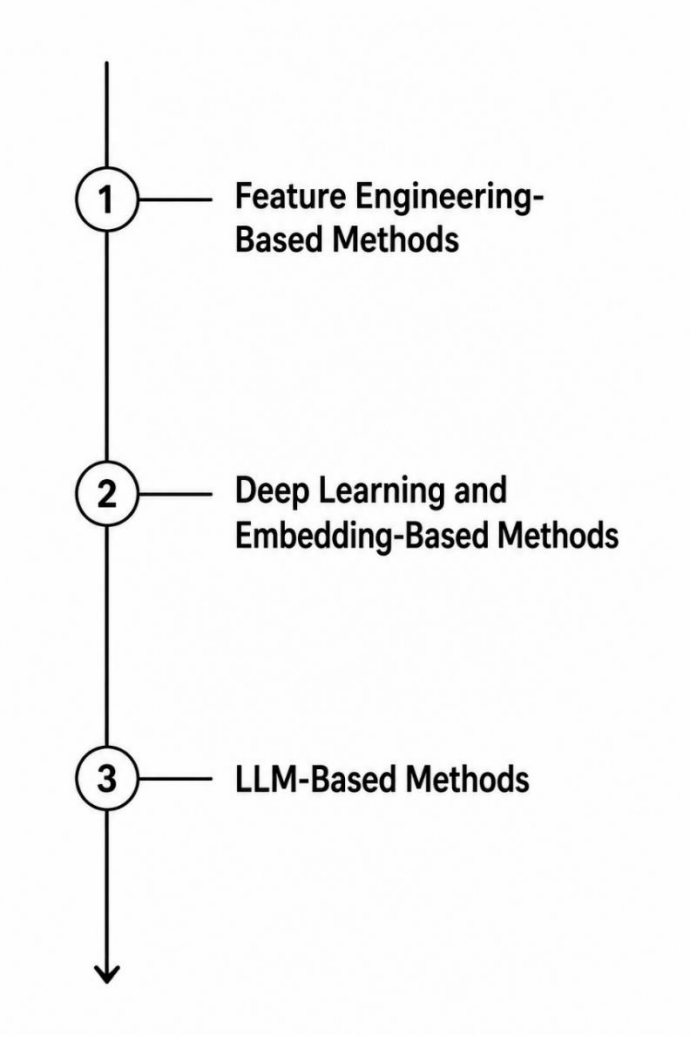
Related Work

We show that existing work overlooked the hierarchical nature of lectures



the dominant modeling paradigm remained focused on detecting local discontinuities

- Inherits flat modeling from other fields like dialogue segmentation, scene change detection.
- limited due to existing flat segmentation annotation

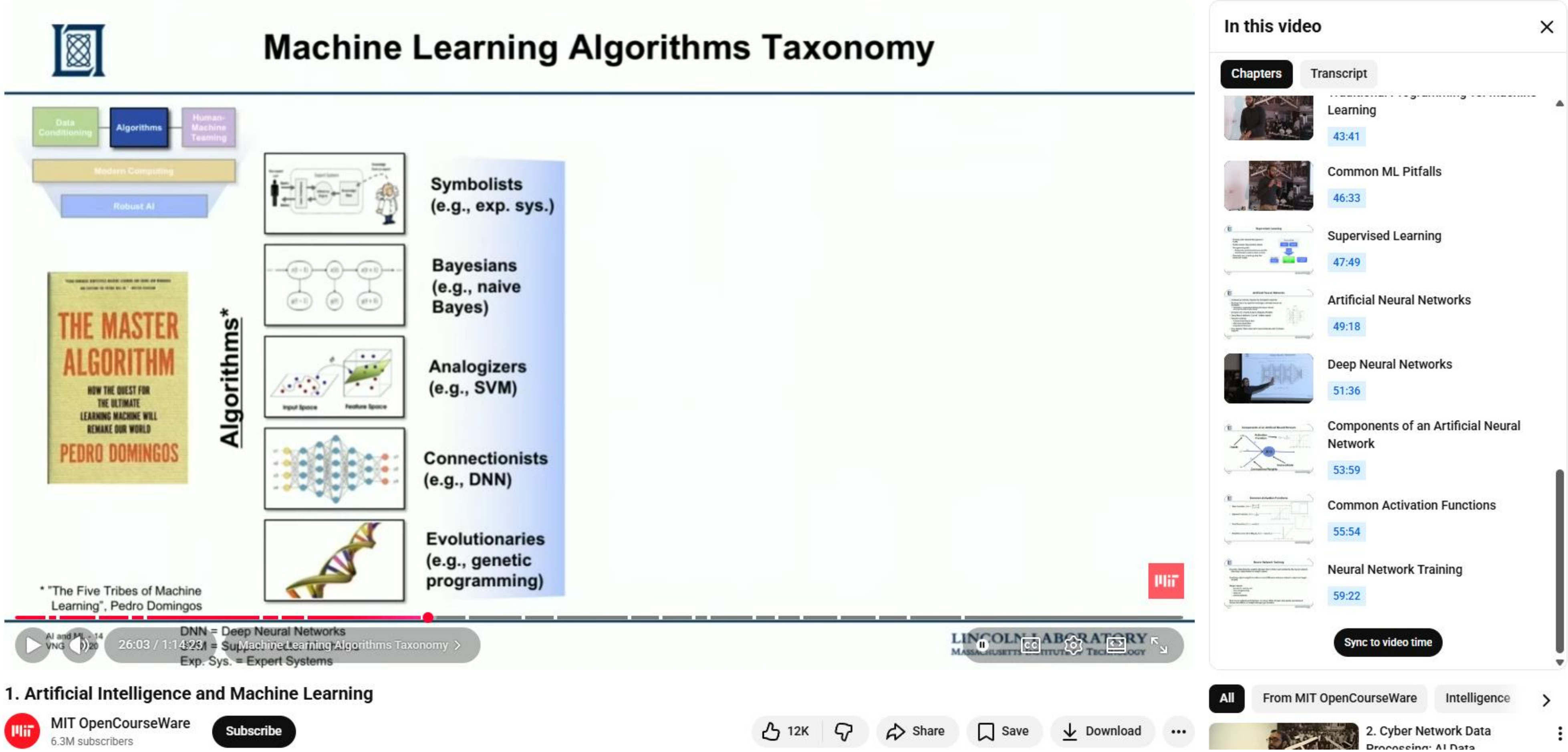
Achieving promising performances. Further illustrating the importance of modeling latent educational logic and hierarchical conceptual organization.

Subjectivity of Manual Annotation

Manual Annotations are subjective.

Different granularity across courses

Different granularity within one lecture


Machine Learning Algorithms Taxonomy
Data Conditioning
Algorithms
Human-Machine Teaming
Modern Computing
Robust AI
THE MASTER ALGORITHM
HOW THE QUEST FOR THE ULTIMATE LEARNING MACHINE WILL REMAKE OUR WORLD
PEDRO DOMINGOS
Algorithms*
Symbolists (e.g., exp. sys.)
Bayesians (e.g., naive Bayes)
Analogizers (e.g., SVM)
Connectionists (e.g., DNN)
Evolutionaries (e.g., genetic programming)
* "The Five Tribes of Machine Learning", Pedro Domingos
DNN = Deep Neural Networks
Exp. Sys. = Expert Systems
26:03 / 1:14:25
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Sync to video time
All
From MIT OpenCourseWare
Intelligence
2. Cyber Network Data

Machine Learning, 23 segments
https://www.youtube.com/watch?v=t4K6[illegible]7Zw, taken on 13.05.2026

Calculus, 9 segments
https://www.youtube.com/watch?v=4sTKcvYMNxk, taken on 13.05.2026

Affects on Segmentation Methods

15 boundary points predicted
6 Ground-Truth boundary points

8 out of 15 predictions are topics of finer granularity

The model
- Unaware of the topic hierarchy
- Cannot identify targeted granularity
- Inherits dataset's bias

Time	GT	Prediction	Remarks
00:02	No	Yes	Sub-topic (Opening Animation)
02:41	Yes	Yes	True positive
06:53	No	Yes	Sub-topic
08:25	No	Yes	Sub-topic
10:07	Yes	Yes	True positive
11:39	No	Yes	Sub-topic
14:30	No	Yes	False positive
17:41	Yes	Yes	True positive
17:59	No	Yes	False positive
26:59	Yes	No	False negative
30:28	No	Yes	Sub-topic
32:17	Yes	Yes	True positive
32:22	No	Yes	Sub-topic
32:24	No	Yes	False positive
33:42	Yes	No	False negative
35:48	No	Yes	Sub-topic
36:36	No	Yes	Sub-topic (Copyright Page)

Case Study of Video_107 from MITFLD with BiLSTM (JVTE) [1]

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Proposed Task

Our goal is to enhance the model's understanding of hierarchical semantics.

we formulate hierarchical pedagogical relation between two educational material

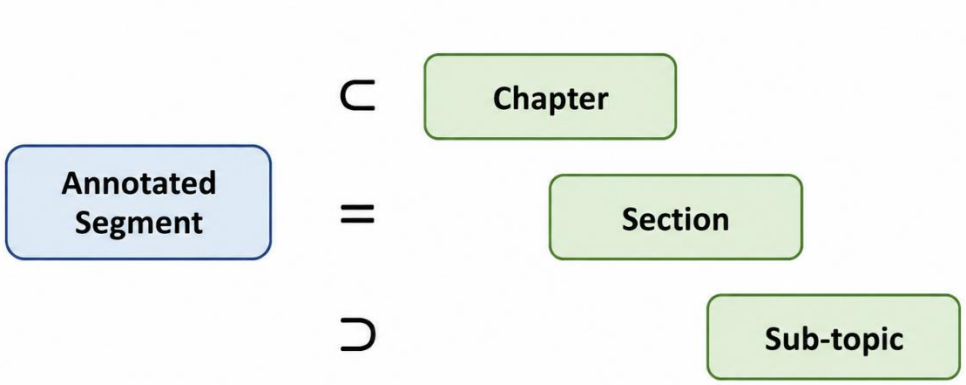
Relation	Mathematical Expression
Equivalent	$A = B$
Parent	$A \supset B$
Child	$A \subset B$
Overlap	$A \cap B \neq \emptyset, A \neq B$
Unrelated	$A \cap B = \emptyset$

Relation Table

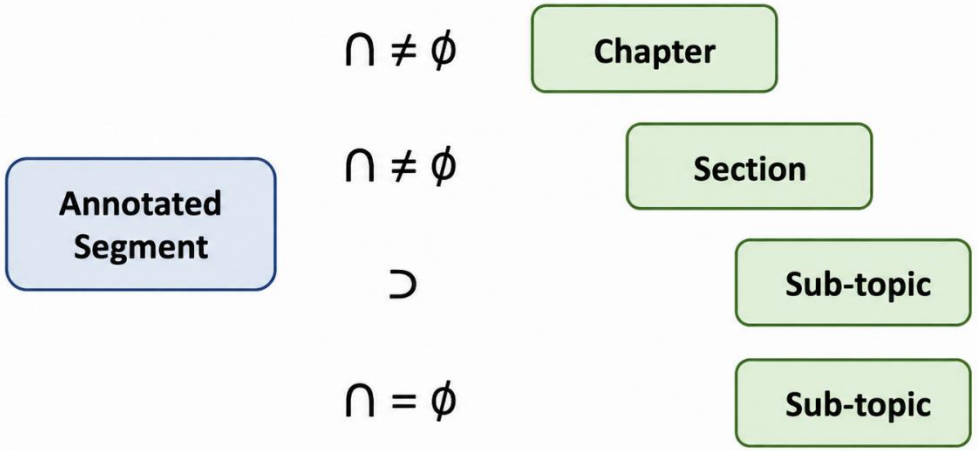
Intuition: a model capable of understanding the hierarchical organization of educational semantics should also be able to infer structured semantic relations between two materials

Data Construction

Due to the shown subjectivity in segmentation annotations, we seek other existing hierarchical semantic information
Textbook is well hierarchically structured.
We can use textbook information to enhance the model's understanding of hierarchical semantics



Fully Equivalent Topic Construction



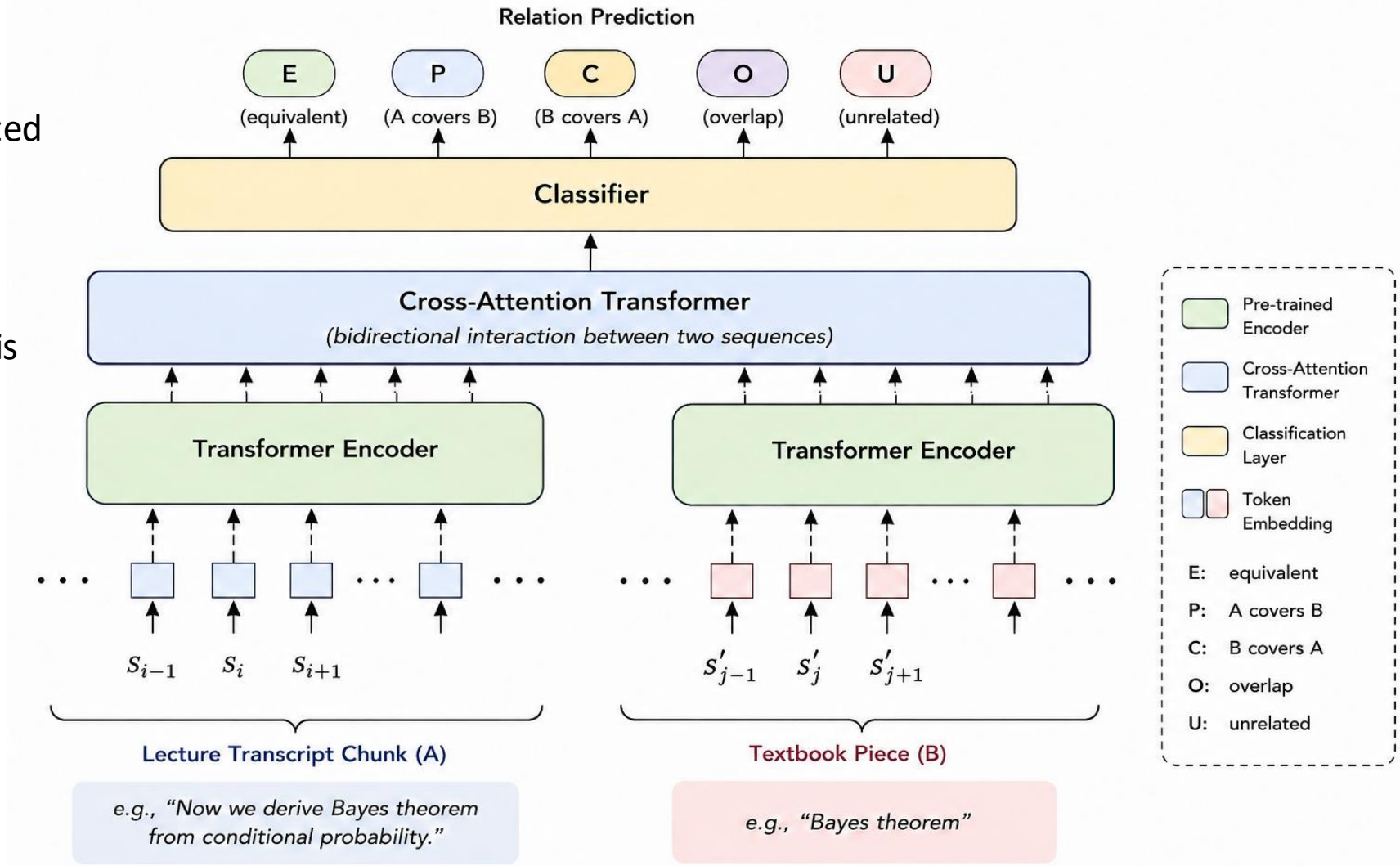
Overlap Topic Construction

By such constructions, we have (lecture segment, textbook piece) -> relation as our data.

Example Training Process

The underlying encoder is expected to learn hierarchical semantics.

Combined with tasks like boundary prediction, the model is expected to reconstruct the hierarchical semantics.



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Future Directions

Evaluation of the hierarchical semantic understanding:

- standard classification metrics
- retrieval-based evaluation settings

Enabling and evaluation of the hierarchical semantic reconstruction is a key challenge:
Existing benchmarks mainly rely on creator-provided chapter boundaries

We hope more explicit hierarchy reconstruction research is proposed.
Future evaluation should therefore combine traditional segmentation metrics with human-centered measures

We will further implement and evaluate the downstream OER reuse tasks inside the our developed OER conversion tool[2] framework:

- Flipclassroom
- Integration
- Retrieval

Conclusion

This work is a conceptual work on

- identifying an existing problem in lecture segmentation,
- proposing an enhancing approach through textbook-lecture piece pairs,
- motivated by facilitating OER reuse.

References

J. Wang, R. Y.-K. Kwok, E. C. H. Ngai, Towards key point identification (kpi) for lecture videos: Approaches and performance evaluation, ACM Trans. Multimedia Comput. Commun. Appl. 21 (2025). URL: https://doi.org/10.1145/3746640. doi:10.1145/3746640.

L. K. N. Ali, convOERter: a technical assistance tool to support semi-automatic conversion of images in educational materials as OER, Ph.D. thesis, RWTH Aachen University, 2024. URL: https://publications.rwth-aachen.de/record/978511. doi:10.18154/RWTH- 2024- 01352, artwork Size: pages 1 Online-Ressource : Illustrationen Pages: pages 1 Online-Ressource : Illustrationen Publication Title: Dissertation Volume: RWTH Aachen University.