# Online Tensor Analysis

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**Abstract**

In this paper, we propose fast and accurate online tensor decomposition method called OnlineTensorAnalysis, a tensor factorization tool for a streaming tensor by drastic data handling. As drastic data income at a certain time step, OnlineTensorAnalysis chooses to split the tensor or update its whole time factor matix. It enhances more accurate and faster decomposition with memory-efficient management of temporal factors.

# 1 Introduction

Given a temporally growing tensor, how can we analyze it efficiently? Multi-dimensional arrays or tensors have been widely used to model real world data. Tensor decomposition plays an significant role in latent feature detection and prediction of unobservable entries. Each tensor can have different lengths of modes and tensors having their size consistent are called static, and the others are called dynamic tensors. Most of existing tensor analysis methods such as CP–ALS or HOSVD decompose static tensors with high fitness. However, applying static tensor decomposition methods to dynamic tensors is actually an inappropriate way in time and space efficiency.

For tensors dynamically growing in the temporal mode (e.g. sensor data on every point of the room), their factorization invokes lots of computations to update all the entries on time factor. Data stream produces numerous amounts of data incomes every second and it became more important to maintain each tensor factorization results. The contributions of this project are the following:

- OnlineTensorAnalysis performs online tensor decomposition preserving accuracy without time dilation due to short data income intervals.
- OnlineTensorAnalysis is time scalable, being linear on the length of temporal mode.
- OnlineTensorAnalysis automatically detects drastic data changes and creates starting points of decomposition for accuracy optimization.

# 2 Preliminaries

## 2.1 Preliminaries

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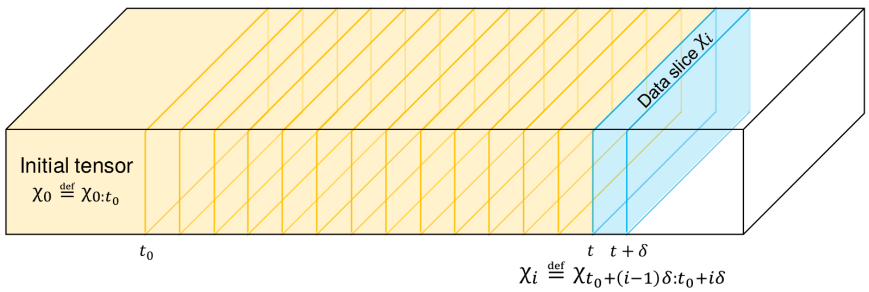
# 3 Proposed Method

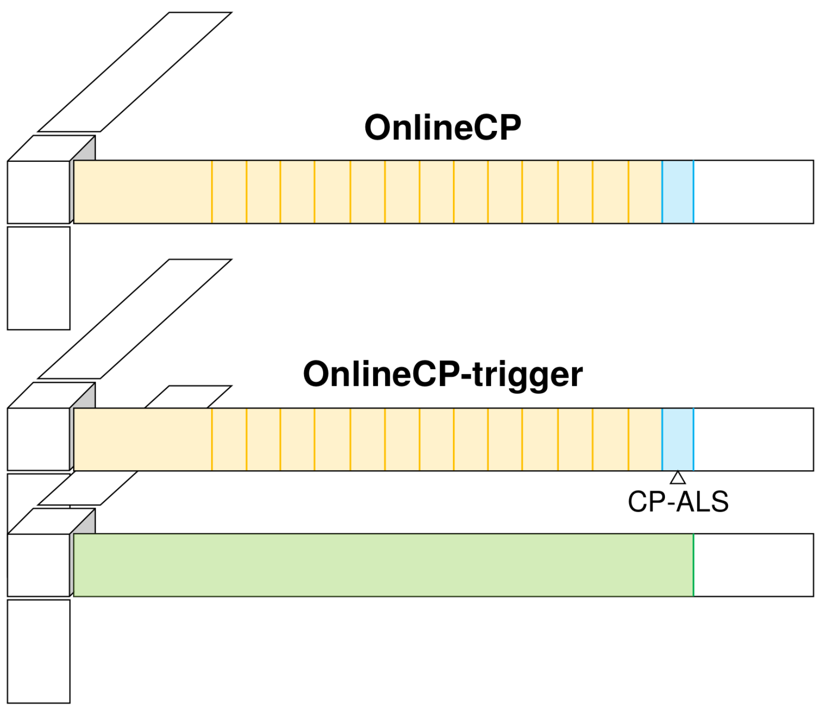
We've developed our methods by extending the basic intuition of OnlineCP. Since dynamic tensor decomposition pursues shorter time factor updates, this will result low accuracy fitting when real-time data incomes. To optimize the speed accuracy problem, we'd like to trigger static decomposition like CP–ALS while dynamic method like OnlineCP is being done.

## 3.1 *OnlineCP-trigger*

**Detection Approach**: CP–ALS activates whole temporal factor updates and enables high accuracy decomposition. Drastic data can be detected with image error norm and its ratio between every neighboring time frame is used to trigger CP–ALS in this approach. The condition for triggering is when temporal ratio of error norm for incoming data exceeds threshold.

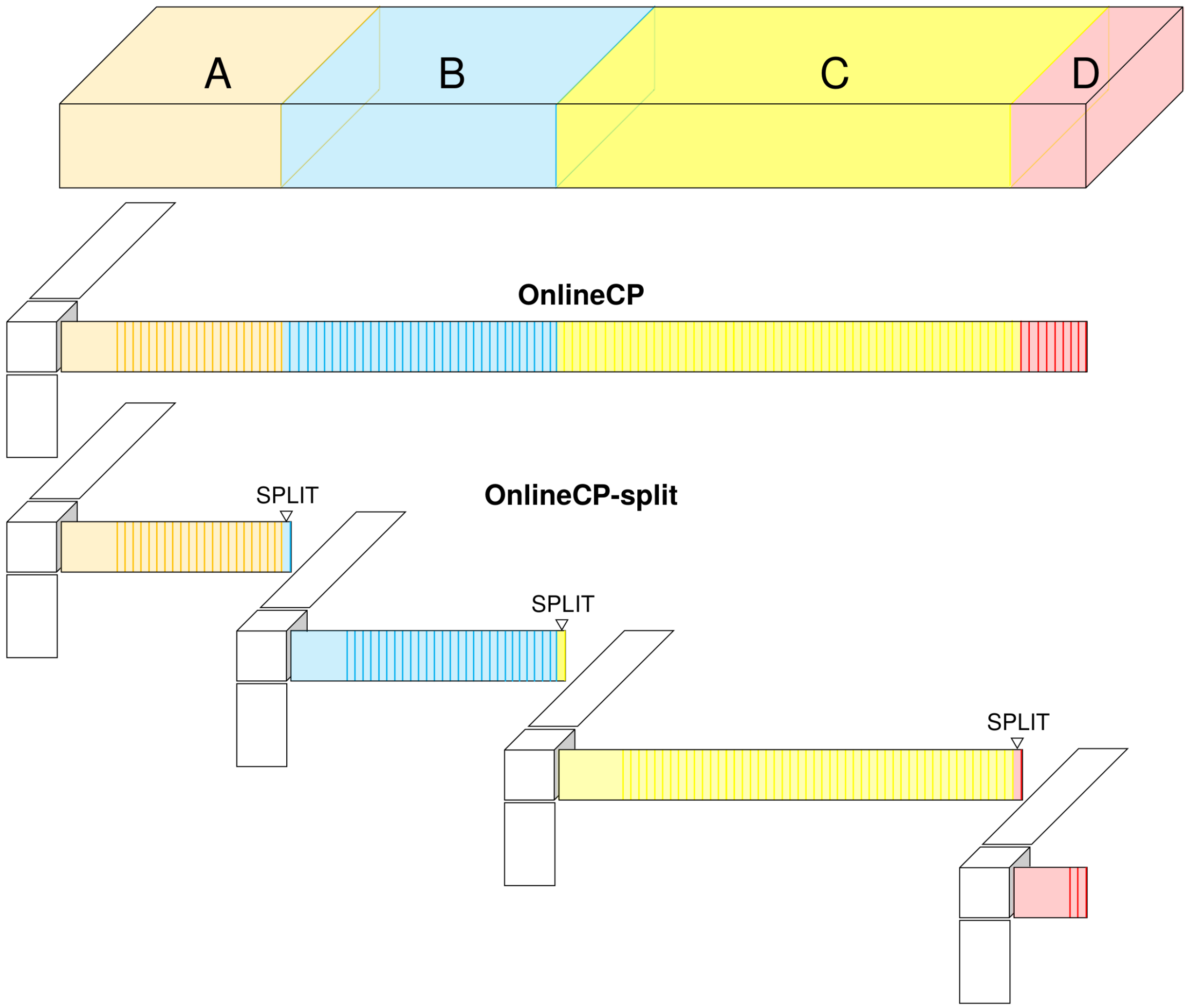
$$threshold < \frac{\|\tilde{\chi}_{i+1} - \chi_{i+1}\|}{\|\tilde{\chi}_i - \chi_i\|}$$



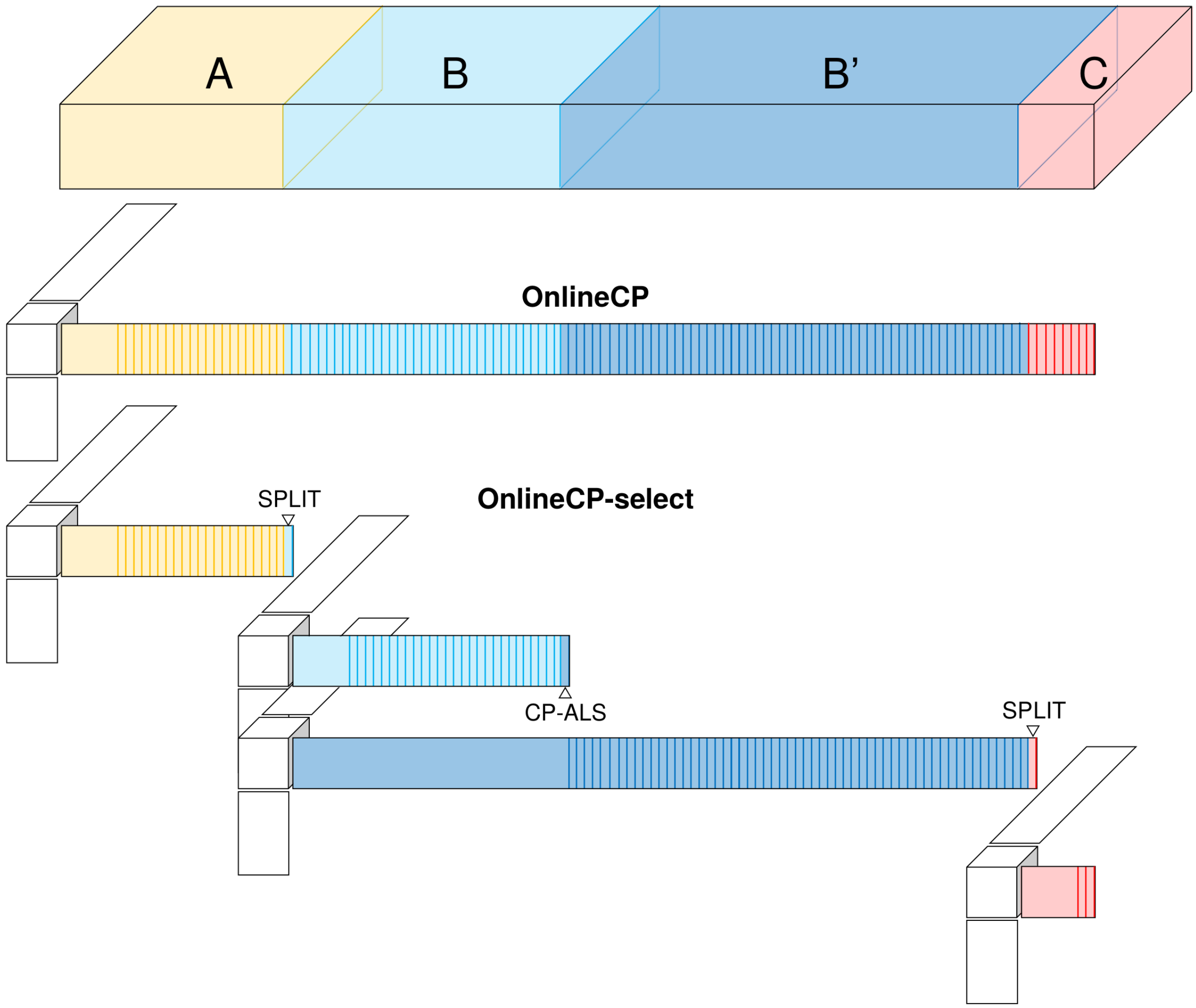
### 3.2 *OnlineCP-split*

**Split Approach**: trigger function in detection approach tells us sudden change in data. What if the incoming data may have a new theme unseen before? It implies that tensor separation and a new decomposition to start are needed. In this approach, we'd like to use the trigger function for splitting tensors to entirely different serial themes. (e.g. $A$, $B$, $C$, $D$)



### 3.3 *OnlineCP-select*

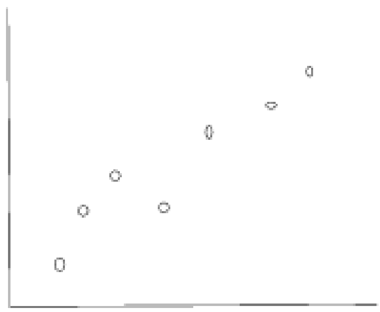
**Selection Approach**: Similarly to split approach, trigger function makes a decision whether to split tensor or not to concatenate tensors behind with temporal factor updates. It allows to store the tensor efficiently; grouping tensors with similar themes and splitting them otherwise. (e.g. $A$, $B$, $B'$, $C$)



## 4 Experiments

We implemented our method and compared it with the older ones. The results are very promising.

Figure 1 shows our results: Figure 1(a) gives a scatter-plot of the $N$ sound-clips, where the axis are the two main features we propose to use ... Figure 1(b) shows the wall-clock time of our method, versus the size of the database $N$.



(a)

(b)

Figure 1: A fictitious dataset (a) and its performance plot (b)

## 5 Related Works

Put related works here.

## 6 Conclusions

The proposed method *someMETHOD* has the following advantages:

- it gives better classification accuracy than all 10 competitors we tried
- its accuracy is very close to the very best competitor in the *UCR Insect Classification Contest.*
- it is scalable

# A Appendix

## A.1 Additional Stuff 1

Put contents here.

## A.2 Additional Stuff 2

Put contents here.