Mr. Shakespeare, Meet Mr. Tucker, Part II

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Objectives

To investigate the use of tensor decomposition in static malware analysis - on a large scale

- Malware analysis is often done "in the small", that is, on one specimen at a time [1]
- We need to do malware analysis "in the large"
- Can we use tensor decomposition to gain insight into large collections of malware?

Building the Tensor

We selected a specific malware family, the well-known Zeus Trojans [2], as test subjects.

The tensor X is constructed so that: for each Zeus file i, entry $x_{i,j,k}$ is how many times 4-gram j occurs in decile k of the file. That is,

- $1 <= i <= 8020$, the number of Zeus specimens available to us
- $1 <= j <= 2^{32}$, the upper bound on the number of distinct 4-grams. The actual number of distinct 4-grams of course varies from file to file.
- $1 <= k <= 10$, since we chose to represent the approximate location in each specimen by dividing each specimen into ten parts of equal length.

Tucker Decomposition from Kolda [3]

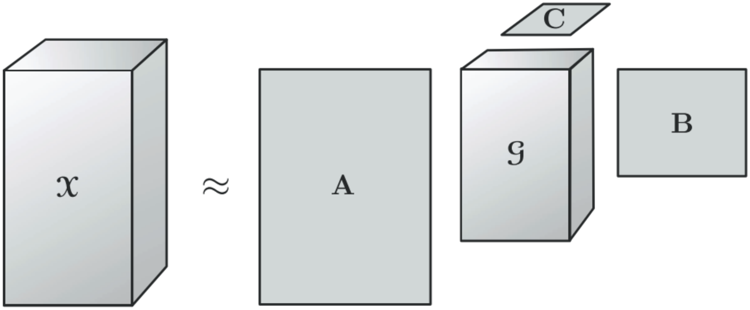
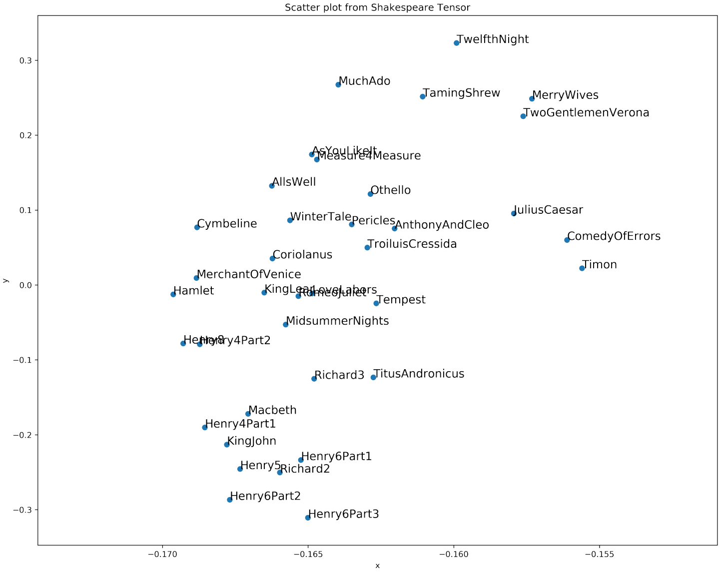


Fig. 4.1 *Tucker decomposition of a three-way array.*

Sanity Check - Shakespeare

Before trying the Zeus data, we wanted to try a smaller corpus - the Shakespearean plays. [4]
Using Python packages `sklearn` (to parse the text data) and `tensorD`[5] and `tensorflow` (to do the tensor calculations), in a Jupyter Notebook, we built the tensor X as described earlier, and ran both HOSVD and HOOI versions of Tucker.

Plot of First Two Factors from Tucker Decomposition



Tensor and Results

- In the Shakespearean tensor X, entry $x_{i,j,k}$ is the number of times word j occurs in Act k of play i. The value of i ranges from 1 to 37, j ranges from 1 to about 30,000, and k ranges from 1 to 5. The tensor is quite sparse.
- Plotting the first two factors produced by HOOI, HOSVD gave similar results
- We are pleased with the (unsupervised!) clustering of the history plays at the bottom of the plot.

Research Continues: Update

- Malware binaries will have *many* more terms than Shakespeare does, so we must be selective.
- Only some of the Zeus binaries are unpacked, so focus on those first.

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