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Title: **EVALUATING STRUCTURAL ENGINEERING FINITE ELEMENT ANALYSIS DATA USING MULTIDAY ANALYSIS**

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EVALUATING STRUCTURAL_ENGINEERING_FINITE ELEMENT ANALYSIS DATA USING MULTIDAY ANALYSIS

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Abstract

The scope of this paper is to introduce multiday analysis into structural engineering research and to outline methodology used in tensor decomposition of finite element analysis (FEA) data. More specifically, the example evaluated herein evaluates the stress distribution of two different highway bridge structural components (girders and cross frames), being subjected to incrementally increasing forces. Additionally, the paper shows potential advantages of using multiday methods in interpretation of FEA data and makes recommendations for future investigations on the use of multiway methods in FEA post processing of structural engineering data.

Introduction

Finite Element Analysis (FEA)

• **Common tool in structural engineering**

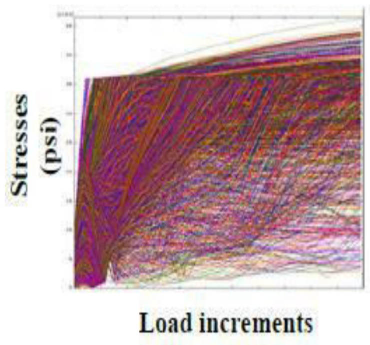
• **Predicts structural** behaviour Based on a discretization of structural parts into geometric shapes (elements)

• **The number of elements in a typical** model could vary anywhere from hundreds to millions

FEA in Current Practice

Only a small fraction of this available data (such as min. and max. stresses) are quantitatively analyzed

Big data techniques provide opportunity for more holistic analysis Likely to be advantageous for comparing differences in competing design options



Goal:

To explore the use of multiway data analysis techniques in analyzing structural engineering FEA output

Scope:

Propose a new procedure for interpreting FEA data in structural engineering

Propose using multiway method (Tucker3 tensor decomposition) in evaluation of FEA data

Make recommendations for future use of multiway tools in structural engineering FEA

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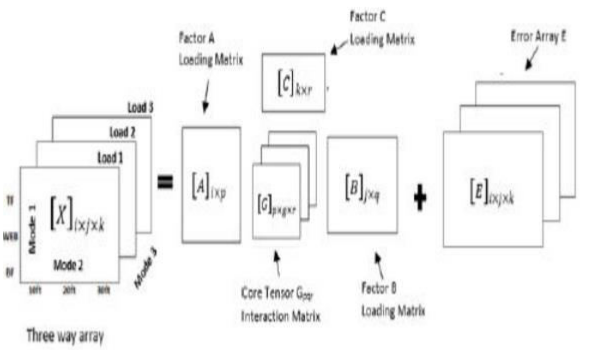
Tucker3 Tensor Decomposition

Type of higher order singular value decomposition

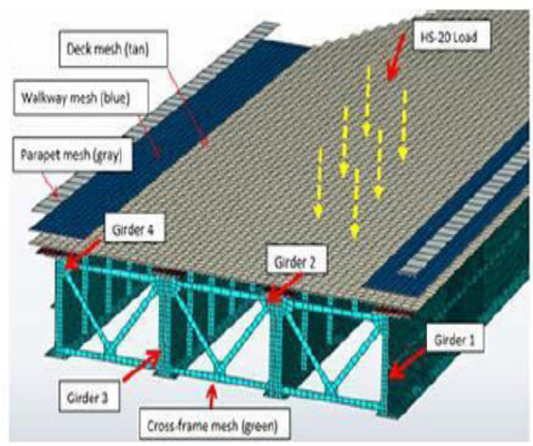
Decomposes 3D array into sets of scores that describe the data in a more condensed form

$$[X]_{i\times j\times k} = [G]_{p\times q\times r} \times [A]_{i\times p} \times [B]_{j\times q} \times [C]_{k\times r}$$

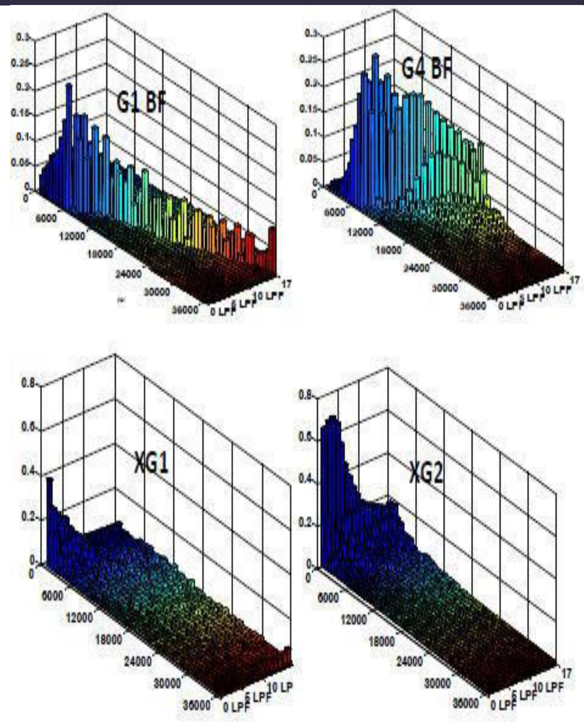


Methodology

FEA Subject Bridge



Data Pre-processing for Tensor Decomposition, cont.



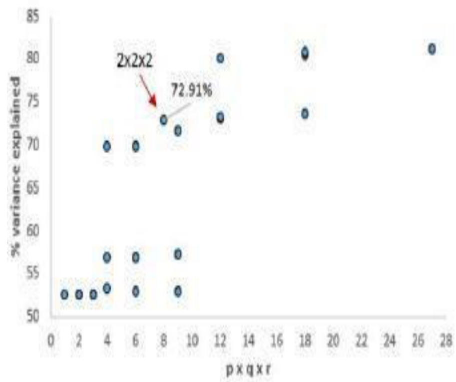
Results

Determining Appropriate Tucker3 Model

Fitting procedure based on:

Percent variance explained

Optimal model complexity



Results: Element Group Loading Scores

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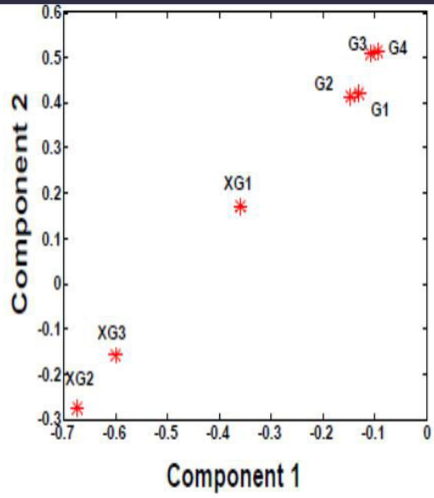
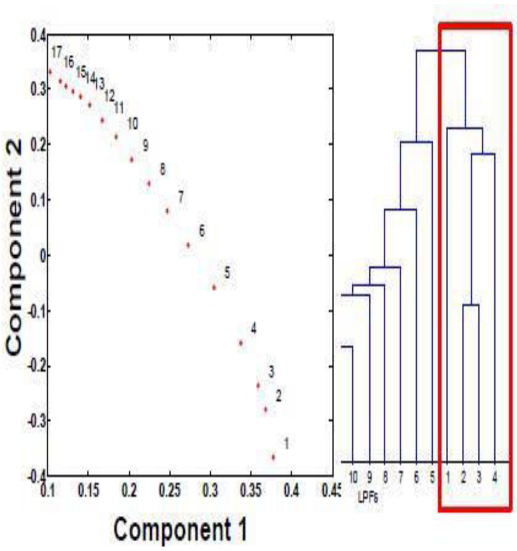


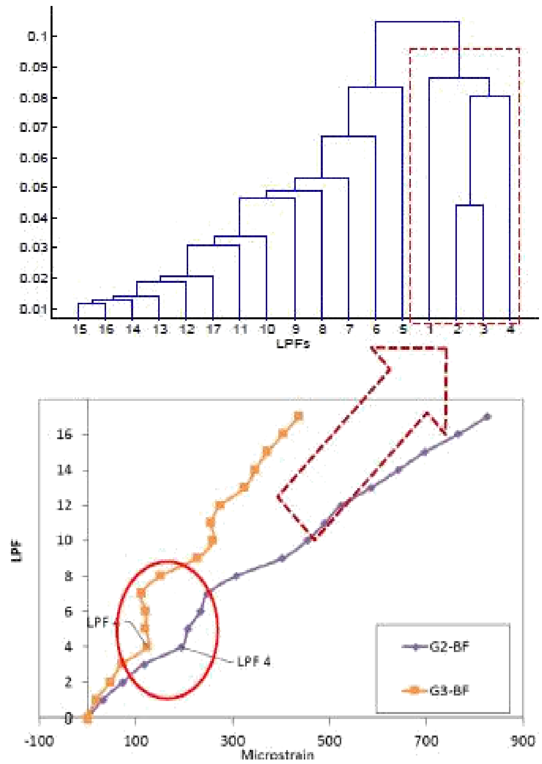
High negative scores in Component 1 - narrowest spread in stress distribution High positive scores in Component 2 - widest spread in stress distribution Results: LPF Loading Scores



High positive scores in Component 1 and high negative scores in Component 2 □ low LPFs

•High positive score in Component 2 □ high LPFs.

Comparing Tucker3 Results to Experimental Results



Conclusion

Innovative method of FEA data interpretation

Possible ability to highlight latent behavior of bridge components subjected to increasing load

•Ability to quantify and differentiate the

stress profiles of different bridge components

References

1. **Lewis Butler** The tests that we actually carry out in the FE is representative of what we try and do on the car each season to verify its overall stiffness.
2. **Dr. Keith Martin, The Open University** It's interesting that Red Bull have carried out detailed measurements of real test chassis tubs at various positions along the

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length-- the best form of verification.

3. **Dr. Keith Martin, The Open University** It's interesting that Red Bull have carried out detailed measurements of real test chassis tubs at various positions along the

   length-- the best form of verification.
4. **Dr. Keith Martin, The Open University** don't forget, in real life the engineers are responsible for making sure that variations
5. **Narrator** If we look at the six degrees of freedom for each node on the cut face, the x-axis is aligned with the car longitudinal centre line.