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A FAST INCREMENTAL MULTILINEAR PRINCIPAL COMPONENT ANALYSIS ALGORITHM

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Abstract. *This study establishes the mathematical foundation for a fast incremental multilinear method which combines the traditional sequential Karhunen-Loeve (SKL) algorithm with the newly developed incremental modified fast Principal Component Analysis algorithm (IMFPCA). In accordance with the characteristics of the data structure, the proposed algorithm achieves both computational efficiency and high accuracy for incremental subspace updating. Moreover, the theoretical foundation is analyzed in detail as to the competing aspects of IMFPCA and SKL with respect to the different data unfolding schemes. Besides the general experiments designed to test the performance of the proposed algorithm, incremental face recognition system was developed as a real-world application for the proposed algorithm.*
Keywords: Multilinear principal component analysis, Fast principal component analysis, Incremental subspace learning, Sequential Karhunen-Loeve algorithm, Mean update

1. **Introduction.** The so-called appearance-based techniques, such as the Principal Component Analysis (PCA) and the Linear Discriminant Analysis (LDA), have been extensively used in the literature with a wide range of applications in fields such as computer vision, pattern classification, signal/image processing, among others. However, their computational complexity and their batch mode computational frameworks still impose practical constraints in applications that demand concurrently faster execution speed and higher accuracy in the results. A variation on the singular value decomposition (R-SVD) [1] provides a faster approach for obtaining a specific subspace of a given data structure. Based on R-SVD, A. Levy and M. Lindenbaum developed the sequential Karhunen-Loeve (SKL) algorithm [2], which is characterized by a faster execution speed and higher suitability for dealing with image sequences. Many other applications were consequently reported by utilizing the SKL algorithm. For instance, D. Ross et al. [3] proposed a visual tracking system based on an incremental subspace method with sample mean update. Also, Zhao et al. [4] developed a novel incremental PCA with specific application to face recognition. Moreover, T. Jun et al. [5] developed the incremental subspace method for kernel PCA, and applied it to offline and online face recognition as well as visual tracking. In study [6], L. Hoegaertsa et al. proposed a method which is similar to the research concept in [4], but extended it into the kernel space and included both updating and downdating procedure for tracking purposes. Another kind of fast principal component extraction method called Principal Component Orthogonal Projection Approximation and Subspace Tracking (PC-OPAST) was introduced in [7] by S. Bartelmaos and K. Abed-Meraim to