AFFINE PROJECTION ALGORITHMS: EVOLUTION TO SMART AND FAST ALGORITHMS AND APPLICATIONS

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ABSTRACT

Affine projection algorithm encompasses a family of configurable algorithms designed to improve the performance of other adaptive algorithms, mainly LMS based ones, especially when input data is highly correlated. The computational cost of the affine projection algorithm depends largely on the projection order, which in turn conditions the speed of convergence, thus high speed of convergence implies usually high computational cost. Some real-time applications (especially multichannel) using the affine projection algorithm can not be implemented in the existing general-purpose hardware, because of this several improvements of the affine projection algorithm have been proposed to make it more computationally efficient and more versatile in terms of performance. This paper outlines the evolution of the affine projection algorithm and its variants, in order to get an efficient and self-reconfigurable algorithm. Furthermore new improvements over the existing low cost and variable step size and projection order versions are proposed to give examples of the new generation of affine projection algorithms.

1. INTRODUCTION

Originally affine projection (AP) algorithms emerged to improve speed of convergence of gradient based algorithms when the input signals did not exhibit flat spectrum, since the speed of convergence of these algorithms decreased substantially in this cases [1].

A common feature that encompasses all AP algorithms is the filter update equation, which uses N (called projection order) vectors of the input signal instead of a single vector as the NLMS algorithm. Therefore, these algorithms could be understood as an extension of the algorithm NLMS, or more generally, as a minimization problem with constraints that can be expressed mathematically as follows.

Let (1) be the change of the L adaptive filter coefficients between successive algorithm iterations,

$$\Delta \mathbf{w}_L[n] = \mathbf{w}_L[n] - \mathbf{w}_L[n-1]. \tag{1}$$

To develop the algorithm the expression (2) has to be minimized under N constraints given by (3):

$$\|\Delta \mathbf{w}_L[n]\|^2 = \Delta \mathbf{w}_L^T[n] \Delta \mathbf{w}_L[n]. \tag{2}$$

$$\mathbf{w}_L^T[n]\mathbf{x}_L[n-k] = d[n-k] \quad \text{para } k = 0, 1, \dots, N-1. \tag{3}$$

$\mathbf{x}_L[n]$ is a vector that comprises the last L samples of the input vector and $d[n]$ represent the desired signal as in is illustrated in Fig. 1.
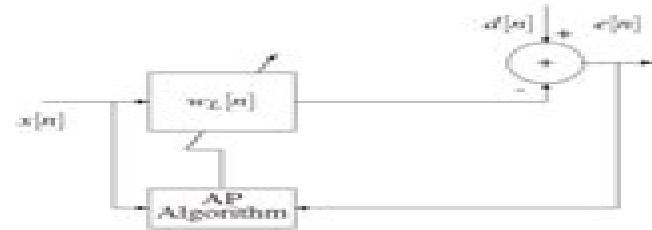

Figure 1: Adaptive scheme and signals involved using the affine projection algorithm.

The solution of the presented problem leads to the AP update equation given by

$$\mathbf{w}_L[n] = \mathbf{w}_L[n-1] + \mathbf{A}^T[n](\mathbf{A}[n]\mathbf{A}^T[n])^{-1}\mathbf{e}_N[n]. \tag{4}$$

where

$$\mathbf{A}[n] = (\mathbf{x}_L[n], \mathbf{x}_L[n-1], \dots, \mathbf{x}_L[n-N+1])^T. \tag{5}$$

$\mathbf{e}_N(n)$ is a vector of size $N \times 1$ given by

$$\mathbf{e}_N[n] = \mathbf{d}_N[n] - \mathbf{A}[n]\mathbf{w}_L[n-1]. \tag{6}$$

and $\mathbf{d}_N[n]$ represents the desired signal vector of size $N \times 1$

$$\mathbf{d}_N^T[n] = (d[n], d[n-1], \dots, d[n-N+1]). \tag{7}$$

Equation (4) can be expressed by a general form, see expression (8), which includes the entire affine projection family.

$$\begin{aligned}\mathbf{w}_L[n] = \mathbf{w}_L[n-1-\alpha(N-1)] \\ + \mu \mathbf{A}_\tau^T[n](\mathbf{A}_\tau[n]\mathbf{A}_\tau^T[n] + \delta\mathbf{I})^{-1}\mathbf{e}_{N\tau}[n]\end{aligned} \tag{8}$$

with $\mathbf{e}_{N\tau}[n] = \mathbf{d}_{N\tau}[n] - \mathbf{A}_\tau\mathbf{w}_L[n-1-\alpha(N-1)]$.

$$\mathbf{A}_\tau[n] = (\mathbf{x}_L[n], \mathbf{x}_L[n-\tau], \dots, \mathbf{x}_L[n-(N-1)\tau])^T \tag{9}$$

Affine Projection Algorithm Matlab Code

Paulo S. R. Diniz

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Sustainable Communication Networks and Application P. Karrupusamy,Joy Chen,Yong Shi,2019-11-06 This book presents state of the art theories and technologies and discusses developments in the two major fields engineering and sustainable computing In this modern era of information and communication technologies ICT there is a growing need for new sustainable and energy efficient communication and networking technologies The book highlights significant current and potential international research relating to theoretical and practical methods toward developing sustainable communication and networking technologies In particular it focuses on emerging technologies such as wireless communications mobile networks Internet of things IoT sustainability and edge network models The contributions cover a number of key research issues in software defined networks blockchain technologies big data edge fog computing computer vision sentiment analysis cryptography energy efficient systems and cognitive platforms **An Invitation to 3-D Vision** Yi Ma,Stefano Soatto,Jana Kosecká,S. Shankar Sastry,2012-11-06 This book is intended to give students at the advanced undergraduate or introduc tory graduate level and researchers in computer vision robotics and computer graphics a self contained introduction to the geometry of three dimensional 3 D vision This is the study of the reconstruction of 3 D models of objects from a collection of 2 D images An essential prerequisite for this book is a course in linear algebra at the advanced undergraduate level Background knowledge in rigid body motion estimation and optimization will certainly improve the reader s appreciation of the material but is not critical since the first few chapters and the appendices provide a review and summary of basic notions and results on these topics Our motivation Research monographs and books on geometric approaches to computer vision have been published recently in two batches The first was in the mid 1990s with books on the geometry of two views see e g Faugeras 1993 Kanatani 1993b Maybank 1993 Weng et aI 1993b The second was more recent with books fo cusing on the geometry of multiple views see e g Hartley and Zisserman 2000 and Faugeras and Luong 2001 as well as a more comprehensive book on computer vision Forsyth and Ponce 2002 We felt that the time was ripe for synthesizing the material in a unified framework so as to provide a self contained exposition of this subject which can be used both for pedagogical purposes and by practitioners interested in this field Adaptive Filters Behrouz Farhang-Boroujeny,2013-04-02 This second edition of Adaptive Filters Theory and Applications has been updated throughout to reflect the latest developments in this field notably an increased coverage given to the practical applications of the theory to illustrate the much broader range of adaptive filters applications developed in recent years The book offers an easy to understand approach to the theory and application of adaptive filters by clearly illustrating how the theory explained in the early chapters of the book is modified for the various applications discussed in detail in later chapters This integrated approach makes the book a valuable resource for graduate students and the inclusion of more advanced applications including antenna arrays and wireless communications makes it a suitable technical reference for engineers practitioners and researchers Key features Offers a thorough treatment

of the theory of adaptive signal processing incorporating new material on transform domain frequency domain subband adaptive filters acoustic echo cancellation and active noise control Provides an in depth study of applications which now includes extensive coverage of OFDM MIMO and smart antennas Contains exercises and computer simulation problems at the end of each chapter Includes a new companion website hosting MATLAB simulation programs which complement the theoretical analyses enabling the reader to gain an in depth understanding of the behaviours and properties of the various adaptive algorithms   Machine Learning Sergios Theodoridis,2015-04-02 This tutorial text gives a unifying perspective on machine learning by covering both probabilistic and deterministic approaches which are based on optimization techniques together with the Bayesian inference approach whose essence lies in the use of a hierarchy of probabilistic models The book presents the major machine learning methods as they have been developed in different disciplines such as statistics statistical and adaptive signal processing and computer science Focusing on the physical reasoning behind the mathematics all the various methods and techniques are explained in depth supported by examples and problems giving an invaluable resource to the student and researcher for understanding and applying machine learning concepts The book builds carefully from the basic classical methods to the most recent trends with chapters written to be as self contained as possible making the text suitable for different courses pattern recognition statistical adaptive signal processing statistical Bayesian learning as well as short courses on sparse modeling deep learning and probabilistic graphical models All major classical techniques Mean Least Squares regression and filtering Kalman filtering stochastic approximation and online learning Bayesian classification decision trees logistic regression and boosting methods The latest trends Sparsity convex analysis and optimization online distributed algorithms learning in RKH spaces Bayesian inference graphical and hidden Markov models particle filtering deep learning dictionary learning and latent variables modeling Case studies protein folding prediction optical character recognition text authorship identification fMRI data analysis change point detection hyperspectral image unmixing target localization channel equalization and echo cancellation show how the theory can be applied MATLAB code for all the main algorithms are available on an accompanying website enabling the reader to experiment with the code

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several modules of the Code Excited Linear Prediction CELP algorithm The authors use the Federal Standard 1016 CELP MATLAB software to describe in detail several functions and parameter computations associated with analysis by synthesis linear prediction The book begins with a description of the basics of linear prediction followed by an overview of the FS 1016 CELP algorithm Subsequent chapters describe the various modules of the CELP algorithm in detail In each chapter an overall functional description of CELP modules is provided along with detailed illustrations of their MATLAB implementation Several code examples and plots are provided to highlight some of the key CELP concepts Link to MATLAB code found within the book Table of Contents Introduction to Linear Predictive Coding Autocorrelation Analysis and Linear Prediction Line Spectral Frequency Computation Spectral Distortion The Codebook Search The FS 1016 Decoder   Adaptive Filtering Primer with MATLAB Alexander D. Poularikas,2017-12-19 Because of the wide use of adaptive filtering in digital signal processing and because most of the modern electronic devices include some type of an adaptive filter a text that brings forth the fundamentals of this field was necessary The material and the principles presented in this book are easily accessible to engineers scientists and students who would like to learn the fundamentals of this field and have a background at the bachelor level Adaptive Filtering Primer with MATLAB clearly explains the fundamentals of adaptive filtering supported by numerous examples and computer simulations The authors introduce discrete time signal processing random variables and stochastic processes the Wiener filter properties of the error surface the steepest descent method and the least mean square LMS algorithm They also supply many MATLAB functions and m files along with computer experiments to illustrate how to apply the concepts to real world problems The book includes problems along with hints suggestions and solutions for solving them An appendix on matrix computations completes the self contained coverage With applications across a wide range of areas including radar communications control medical instrumentation and seismology Adaptive Filtering Primer with MATLAB is an ideal companion for quick reference and a perfect concise introduction to the field   **MATLAB® Software for the Code Excited Linear Prediction Algorithm** Karthikeyan Ramamurthy,Andreas Spanias,2010-03-03 This book describes several modules of the Code Excited Linear Prediction CELP algorithm The authors use the Federal Standard 1016 CELP MATLAB software to describe in detail several functions and parameter computations associated with analysis by synthesis linear prediction The book begins with a description of the basics of linear prediction followed by an overview of the FS 1016 CELP algorithm Subsequent chapters describe the various modules of the CELP algorithm in detail In each chapter an overall functional description of CELP modules is provided along with detailed illustrations of their MATLAB implementation Several code examples and plots are provided to highlight some of the key CELP concepts Link to MATLAB code found within the book Table of Contents Introduction to Linear Predictive Coding Autocorrelation Analysis and Linear Prediction Line Spectral Frequency Computation Spectral Distortion The Codebook Search The FS 1016 Decoder   **Feature Extraction and Image Processing** Mark S. Nixon,Alberto S. Aguado,2008 Essential reading for engineers and

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