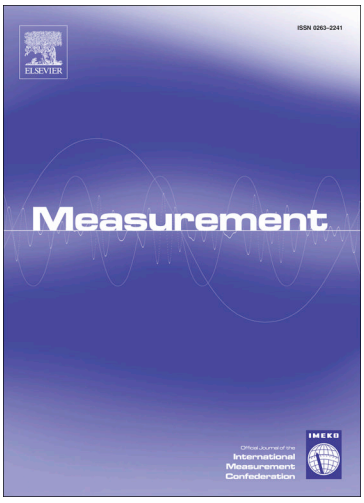


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# The use of MD-CUMSUM and NARX neural network for anticipating the remaining useful life of bearings

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**Abstract:**

The accurate determination of remaining useful life (RUL) of bearings is of immense importance in the condition-based maintenance of any rotating machinery. In this paper, a data driven prognostic approach based on nonlinear autoregressive neural network with eXogenous Inputs (NARX-NN) in combination with wavelet-filter technique is applied to the RUL estimation of bearings. Firstly, the vibration signals generated in an experimental test rig are processed with the proposed wavelet-filter to augment the impulsive characteristics of bearing signals and improve the quality of fault feature extraction. Secondly, a variety of time-domain features are extracted from the processed bearing signals. However, these features exhibit a highly non-monotonic behaviour as the bearing condition degrades. To overcome this drawback, a new health indicator (HI) based on Mahalanobis distance (MD) criterion and cumulative sum (CUMSUM) chart is proposed in this paper. Thirdly, the NARX-NN is first designed as a time delay neural network (TDNN). Then, the derived HI and the age of the bearing are used as inputs with life percentage of the bearing as output in order to train the TDNN model, which unlike the usual artificial neural networks (ANNs) performs a one-step ahead prediction of the bearing RUL. The results suggest that the proposed method can effectively predict the RUL of bearings with an acceptable degree of accuracy, and outperforms the use of self-organizing map-based indicator and the traditional FFNNs for RUL inference.

**Keywords:** Rolling element bearings, Prognostics, Health indicator, NARX neural network, Remaining useful life.

## 1. Introduction

Rolling element Bearings (REBs) constitute the most critical components of any rotating machinery. According to the literature [1], 40–50% of all motor failures occur due to the malfunctioning of bearings. As a consequence of this, catastrophic breakdown of the machinery is inevitable. This in turn increases the machine downtime and overhauling costs causing huge economic losses to the industry. The development of an efficient maintenance strategy therefore becomes necessary to guarantee the proper functioning of the rotating machinery. Recently, condition-based maintenance (CBM) has evolved as a competent maintenance technique and being widely utilized by the industries. In CBM, maintenance events are planned before the failure of the machinery thereby reducing the jeopardy of terrible breakdowns and hence