# NIRS-Based Measurement of Cerebral Autoregulation using Data Clustering Techniques

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**Introduction:** Cerebral blood flow is regulated over a range of systemic blood pressures through the Cerebral Autoregulation (CA) control mechanism [1]. The near infrared spectroscopy (NIRS)-based COx measure has been proposed as a suitable proxy for blood flow in the analysis of CA. Data binning is employed as standard in the method, and a thresholding is then employed to determine the transition between intact and impaired autoregulation zones. We have developed novel data clustering techniques based-on the raw (unbinned) COx data to delineate impaired and intact CA regions.

**Method:** K-means and Gaussian mixture model algorithms were used to analyze a porcine data set. The determination of the lower limit of autoregulation (LLA) was compared to a traditional binned COx approach. The algorithms are more fully described by the author's elsewhere [2]. The k-means algorithm was run 10 times to reduce the risk of being caught in local minima. The square of the Euclidean distance was employed as the distance metric. In the GMM model two Gaussian distributions were fit to the data using an expectation maximization algorithm. The posterior probability of membership for each point was calculated for the resulting two Gaussian distributions. A point is then said to be a member of the cluster for which it has the highest posterior probability. The whole algorithm was repeated in a similar manner to the k-means method to mitigate the effect of falling into local minima in the optimization process.

**Results:** Figure 1(a) shows the traditional COx curve from an animal study. This binned format, is traditional for viewing COx data [3-6]. However, we have found that binning often makes it difficult to produce a robust automated algorithm to determine LLAs due to the granular nature imposed on the bin-aggregated data. The raw (unbinned) data used to construct the COx curve is also given in figure 1(b). We can see by eye that the data is clustered into two distinct regions: one below the lower limit of autoregulation (LLA) where the data is tightly packed around a value of unity. This denotes the impaired CA region where blood pressure and flow are linearly correlated. In this region BP is driving flow through the brain, i.e. the brain is not regulating flow. The second region comprises data spread across the COx limits between 1 and -1: this denotes the intact region where there is no distinct correlation between blood pressure and flow. The LLA's are set automatically by the clustering methods: shown in figure 1(c) and 1(d).

**Conclusions:** Good agreement was found between the LLA determined by the k-means method, GMM method, the traditional COx method and that determined by visual inspection of the data (agreement between 3 observers). The work highlights the potential application of using data clustering tools in the monitoring of cerebral autoregulation function.

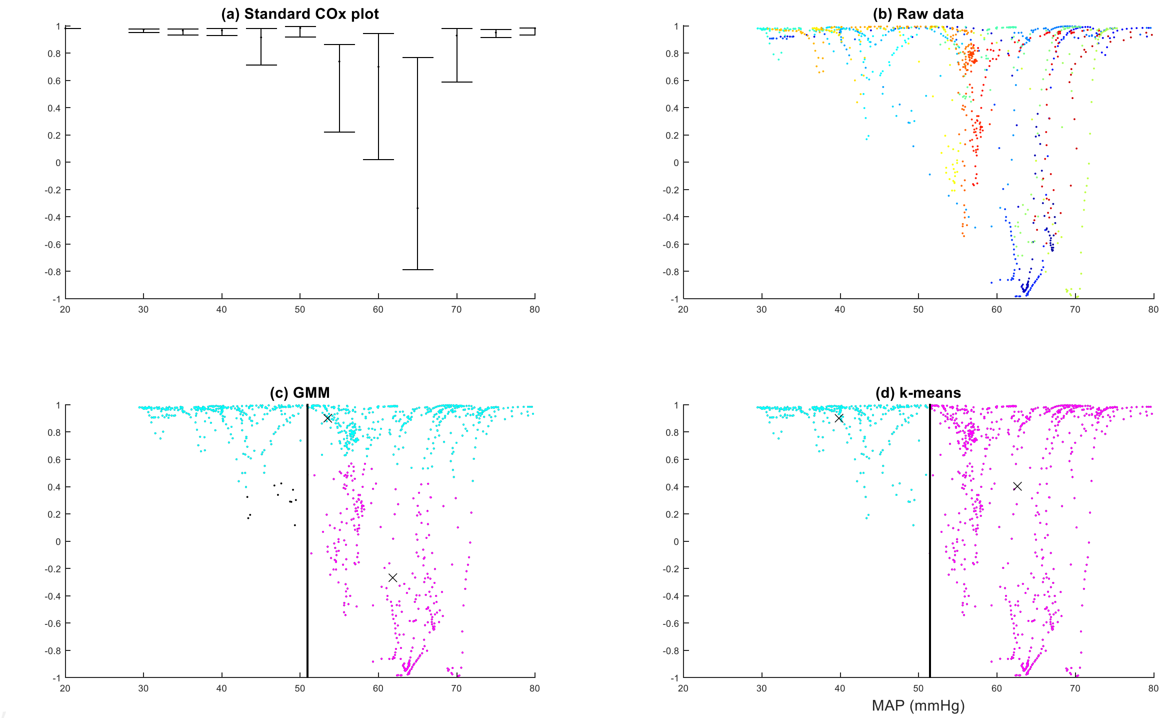


Figure 1. (a) Standard COx curve (b) The raw COx data (c) GMM clustering applied to the raw data (d) K-means clustering methods. LLAs are denoted by the vertical lines.

## References:


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