多變量製程能力指標：分佈和推論之性質

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摘要

　　在製造業中，製程能力指標一直被廣泛地使用，其依據所設定的製造規格來量測製程重複製造產品的能力。根據所計算的製程能力指標值，我們可以清楚的知道目前的製程是否符合製程能力的要求。在單變量製程的特性方面，一直有非常多的文章在探討；然而對於牽涉到多重品質特性的多變量製程之品質測量上，卻鮮少有文章來探討它。本文的具體貢獻主要有三方面：第一方面、我們藉由主成分方法應用 S_{pk}^T 計算多相關品質性特製程的製程良率，而且介紹主成分分析方法和如何應用它和 S_{pk}^T 來獲得良率的信賴下界。第二方面、我們以兩個常被使用的多變量製程能力指標 MC_p 和 MC_{pm} 來評估多變量製程的製程能力。對於 MC_p 指標，我們調查其估計式的統計性質，而依據其統計性質，我們更進一步對真實參數值進行假設檢定、臨界值計算和信賴下界的求取。此外，我們也求出 MC_{pm} 的近似信賴區間。並以一個模擬實驗來驗證信賴區間之準確性。最後一方面、我們依據製程精確性 MC_p 指標來考慮供應商的選擇問題。我們推導出測試的統計量分佈並且依據臨界值來做為兩個製程優劣的比較。以上所提出的方法對於管理者來說是非常有用的，他們可以根據所介紹的方法來判定目前的生產製程是否可以滿足預設的製程能力要求，並且在供應商的選擇上能夠做出更可靠的決定。

關鍵字:製程能力指標、品質特性、PCA、信賴下界、假設檢定、臨界值

Multivariate Capability Indices：
Distributionaland Inferential Properties

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Abstract

Process capability indices have been widely used in the manufacturing industry for measuring process reproduction capability according to manufacturing specifications. Most researches have been devoted to capability measures with single quality characteristic. However, it is quite common that the manufactured product involves more than one quality characteristic. Properties of the univariate processes have been investigated extensively, but are comparatively neglected for multivariate processes where multiple dependent characteristics are involved in quality measurement. The concrete contributions of this dissertation are threefold. First, we propose the approach to calculate the process yield using S_{pk}^{T} through PCA for processes with correlated multiple quality characteristics. We present the PCA method and the procedure of obtaining the lower confidence bound (LCB) for the true process yield using S_{pk}^{T} through the principal component analysis (PCA). Second, we consider two commonly used multivariate capability indices MC_p and MC_{pm}, to evaluate multivariate process capability. We investigate the statistical properties of the estimated MC_p and obtain the lower confidence bound for MC_p. We also consider the problem of testing MC_p, and provide critical values for determining if a multivariate process meets the preset capability requirement. In addition, an approximate confidence interval for MC_{pm} is derived. A simulation study was conducted to ascertain the accuracy of the approximation. Finally, we consider the supplier selection problem based on manufacturing precision MC_p in which the processes involve multiple quality characteristics. We derive the distribution of the corresponding test statistic, and calculate critical values required for the comparison purpose. The proposed procedures are useful for the practitioners to determine whether their production meets the present capability requirement, and make reliable decisions in their in-plant applications involving supplier selections.

Keywords: Process capability indices, quality characteristic, PCA, lower confidence bound, hypothesis testing, critical value

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