Center for e-Design (eDesign)

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Design Analytics Systems

The Customer Service Life Cycle (CSLC) system describes services that a medical device user/customer receives throughout a product's lifecycle. Medical device lifecycle stages include: requirements, acquisition, ownership, and retirement. However, most current design analytics systems ignore the costs associated with ownership and retirement. Maintenance cost, for example, is considered a primary cost of medical devices but they are often not captured in the current practices. These costs, however, are usually hidden within the activities of processing and reprocessing the devices.

One of the main challenges to mechanical systems, including reusable medical equipment, is identifying the relevance of cost factors of maintenance activities for specific devices. It requires significant research to extract related maintenance cost factors from devices' unstructured databases. Forecasting additional costs for system acquisition using design and process characteristics also requires significant research. It is also a challenge to identify implicit relationships between the device and equipment lifecycle factors of maintenance, acquisition, ownership, and retirement.

Potential use of this outlier detection algorithm could enhance medical equipment evaluation and analysis, for example, in an endoscope.

To extract needed cost factors from unstructured data repositories, this breakthrough systematically identifies relationships between design, process characteristics and cost factors. This is achieved by first defining the taxonomy of design and process characteristics, then finding the explicit and implicit cost factors within historical data (which is potentially linked with design and process characteristics). Learning algorithms are being developed by eDesign researchers to improve device costs prediction by more fully understanding relationships between the factors.

Proper medical equipment repair history can reside in extremely complex sets of multivariate data. These contain both continuous and categorical variables. Hence, a variety approaches are required in order to adequately model these the variables in order to analyze the maintenance history data. To improve the safety and reliability of the medical equipment eDesign researchers identify abnormal cases, such as high frequency and cost of maintenance. They accomplish this by detecting outliers. In general, outliers can be detected using distance-based clustering algorithms. Algorithms like Attribute Value Frequency (AVF) and Outlier Detection for Mixed Attribute Datasets (ODMAD) are applicable for both continuous and categorical variables. For instance, endoscopes are one of the most widely used equipment in medical facilities. The Customer Service Life Cycle (CSLC) system found from data that a purchased endoscope used for surgery high cost repairs. As a result, the expected life of an endoscope is relatively less compared to microscope. To validate this conclusion researchers used an actual repair history dataset from non-profit medical facilities. Use an outlier detection algorithm to enhance medical equipment evaluation and analysis. Results should be applicable to any company or organization that uses devices that require significant processing and reprocessing (e.g., medical and hospice facilities, remanufacturing companies, equipment reprocessing companies).

> **Economic impact**: The web-based design analytics system for developing and sharing medical equipment's total cost assessment information can potentially support purchase and retirement decisions and other comparative analyses. Trends from recorded traces of device maintenance, replacement, failure, and other incurred costs can be analyzed and displayed in the developed design analytics system. This system provides two modules: 1) a module for activity based costing from text analysis and data mining that extracts cost information from legacy data warehouses, and; 2) a visualization module to provide users with a conceptual understanding of the attributes associated with the decision information. This information is useful for medical device tactical acquisition, use and strategic planning.

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