LASR: A NEW ANALYTICAL TOOL TO INCREASE INFORMATION RETRIEVAL FROM COMPLEX IMAGES

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INTRODUCTION

Interface pressure mapping has been used in research settings for many years, most commonly in the evaluation of seating pressure distributions. Over the past decade, improvements in pressure monitoring technology have led to increasing acceptance in clinical use. However, this brings with it other issues to be considered: evaluation conditions are not as closely controlled as in a research setting and repeated evaluations are often required. Current image analysis is often limited to subjective evaluation of pressure maps, with minimal numerical indices; and gives no objective indication of the significance of any pressure changes observed. Furthermore, intra-assessment comparison of pressure images may be complicated by relative subject movement between assessments. These factors thus limit the clinical utility of the information collected.

We have developed a novel multi-stage image analysis technique that employs data -mining approaches to maximize information retrieval [1]; The LASR (longitudinal analysis and self-registration) tool incorporates fast registration schemes with a customized false-discovery-rate (FDR) controlled statistical procedure.

METHODS

The LASR tool was applied to data obtained from a longitudinal study of the effects on tissue health of using regular gluteal neuromuscular electrical stimulation (NMES) [2]. Repeated assessments of interface pressures were obtained using a Tekscan CliniSeat multi-cell sensor mat (Tekscan Inc., Boston MA). At each assessment, the interface pressure sensor mat was placed over the subject's cushion in the wheelchair prior to transfer. Seating interface pressures were evaluated with the subject sitting still, with no movement or pressure relief procedures, at a scan rate of 2Hz for a 200s period to give a 400 frame 'static data' movie.

The assessment protocol produced large volume data files for a relatively small number of subjects - a statistical challenge known as "huge-p, small-n" problem. In addition, a true reproduction of seating posture on each visit was not always feasible. The LASR algorithm uses a multi- stage procedure to sequentially address these challenges;

Step 1: Spatially register all images using customized self-registration scheme for images with no fixed landmarks.

Step 2: Create pixel-by-pixel (and frame-by-frame) difference images and movies.

Step 3: Filter difference images using local-polynomial smoothing.

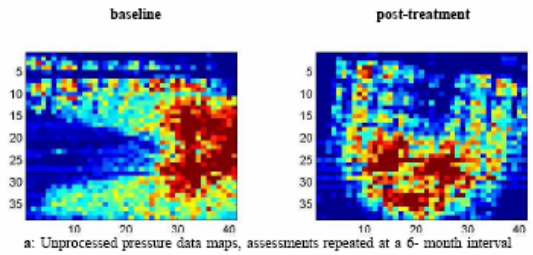
Step 4: Create T image/maps and movies by computing test statistic T_x based on neighborhood weighted averages.

Step 5: Compute FDR-controlled P maps and movies with controlled global error rate.

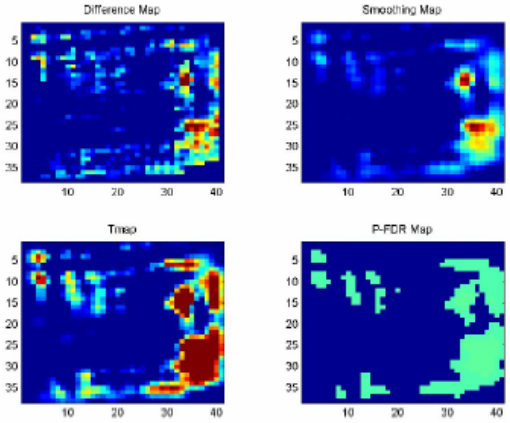
The LASR output map gives a global representation of statistically significant pressure changes. In the clinical application presented, LASR indicates if NMES effectively alters seating interface pressures, with a FDR of <0.05.

RESULTS AND DISCUSSION

Typical LASR analysis output is illustrated in the following case study: Pressure mapping assessment for subject Y showed poor spatial alignment, with both translation and rotation occurring between the baseline and post-treatment images (Figure 1a). Qualitative evaluation of longitudinal changes was difficult. After applying the LASR algorithm it could be seen that pressures were reduced bilaterally over time (Figure 1b). The left and right sacro-ischial regions were equally affected.



a: Unprocessed pressure data maps, assessments repeated at a 6- month interval



b: LASR analysis of long-term changes in static mode seated pressure distribution

Figure 1: Pressure mapping analysis using LASR

CONCLUSIONS

The LASR tool allows useful quantitative information to be derived from pressure mapping images. In the specific study, LASR analysis showed that statistically significant changes occurred in the ischial region over time. Using LASR we can confirm that NMES improves seating interface pressure distributions thus reducing the risk of developing pressure ulcers.

LASR is an analytical technique to compare 3-D images with no fixed landmarks with many potential applications in the field of image analysis and promises to become a powerful new tool for clinicians and researchers.

REFERENCES:

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