Introduction

Exercising is increasingly popular as 45 million American adults have gym memberships. Ironically, there is an estimated 35 percent increase in workout-related injuries these years. Unsuitable workout and poor posture can cause people overactive or under-active muscles, which can lead to incorrect joint motion and an increased risk of fitness injuries. Many people use personal trainers and take a fitness assessment before creating a personalized workout plan. Unfortunately, the cost of this service makes it unaffordable for many people. Finally, these assessments can be subjective with results varying depending upon the trainers.

Solution

FSAT guides users in performing the Overhead Squat (OHS) exercise. Users’ images captured from a Kinect for Windows sensor are processed to extract key characteristics of body parts and calculate angles between them. Implemented Support Vector Machine (SVM), the system automatically assesses users’ mobility and stability in the kinetic chain, and then recommend to users a specific regime of exercises to strengthen weaknesses and address imbalances.

Users are observed at kinetic chain to identify eight possible compensations. They are body compensating for muscular imbalances.

Anterior View

- Feet out
- Knees move inward
- Knees move outward

Lateral View

- Arms fall forward
- Heels rise
- Low back arches

Data acquisition

- Track Head joint position (in anterior view) and Spine joint position (in lateral view) returned by a Kinect for Windows sensor.
- Capture color, depth, skeleton frames at the lowest position of users doing OHS.

Feature Extraction

- Use skeleton joint positions as reference for creating regions of interest.
- Apply image processing techniques such as morphology, Canny edge detection, Hough transform, line fitting in depth and color images.
- Extract curvature of arcs or angles between edges of body parts and the horizontal line.

Classification

- Collect training data from 150 volunteers for classification.
- Analyze collected data by investigating outliers in data scatter plots.
- Deploy SVM method with the features extracted from collected data to determine “compensation” or “not compensation”.

Design

- Feature extraction
- Data acquisition
- Data processing
- Classification

Performance

A trial session was conducted in PSU Recreation Center to test accuracy, response time, robustness of FSAT, and get user reviews with 38 volunteers and one personal trainer.

Accuracy is percentage of assessment results where FSAT and personal trainers are in agreement for all compensations.

Response time is interval between when user finishes OHS and when system displays the result on the screen.

<table>
<thead>
<tr>
<th></th>
<th>Achievement</th>
<th>Requirement</th>
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<tbody>
<tr>
<td>Accuracy</td>
<td>89.03%</td>
<td>&gt;85%</td>
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<tr>
<td>Response time</td>
<td>4.95s</td>
<td>&lt;30s</td>
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<tr>
<td>User review</td>
<td>4.5 stars/5</td>
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</table>

Conclusion

FSAT successfully solves the demand of an automatic system to assess users’ fitness with high accuracy, fast response time and friendly user interface. In the future, FSAT can be upgraded by:

- Further improve accuracy by training with more training instances
- Incorporate database
- Allow subsequent assessment of users
- Extend system to train and evaluate trainers to do OHS assessment
- Visualize assessment results and recommended exercises graphically

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