Intention Based Upper-limb Exoskeleton

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Intention Based Upper-Limb Exoskeleton

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Abstract
Exoskeletons, a wearable robot that intelligently augments the physical power of a human being. These robots are used in military and similar applications. The idea behind the ‘intention based approach’ is that an array of compliant force sensors will continuously monitor the movement of the limb and then map the filtered data to drive the respective actuator which in turn helps in doing the same ‘movement’ with augmented power and better stability.

Concept
• Actuators augment the natural joint torque.
• Circular array of force sensors determine differential load/intention.
• Sensors at different spatial positions are continuously mapped to a set reference.
• 12 bit Quadrature encoder determines the joint positions indirectly.
• 9 DoF Inertial Measurement Unit (IMU) serves as another input to overcome spatial disorientation.
• Extended Kalman Filter (EKF) estimates the actual spatial joint positions in 3D space.
• Based on intention, a differential signal is filtered and fed to the micro-controller (uC) for mapping & eventually to the actuators.

Mechanism
• Simple cam and pin setup. (3DoF)
• Pin glides over two slots with different geometries.
• This makes one body to move wrt. another.
• Allows to have mechanical constrains for safe actuation.

Sensor Array
• 8 Force sensors equally spaced at 45º.
• 130µm fractional change per N.
• Resistivity decreases as load goes up.
• All the analog sensor output is fed to the Analog to Digital Converter (ADC).
• Inertial Reference System (IRS) uses accelerometer, gyroscope and magnetometer (all 3DoF) to keep the track of spatial motion.
• EKF implementation for quadrature encoder and IRS to create simultaneous mapping of input to the actuators.
• Limited only to the radial intention detection.

Material & Study
• 3D printed parts with ABS plastic.
• Static load analysis for 160N.
• Ease of prototyping.

Safe joint rotation range:

<table>
<thead>
<tr>
<th>Joints</th>
<th>Na</th>
<th>Median</th>
<th>Normal R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder Flexion</td>
<td>108</td>
<td>119 (10-153)</td>
<td>150-180</td>
</tr>
<tr>
<td>Shoulder</td>
<td>117</td>
<td>98 (75-130)</td>
<td>180</td>
</tr>
<tr>
<td>Wrist Flexion</td>
<td>109</td>
<td>55 (30-75)</td>
<td>60-80</td>
</tr>
<tr>
<td>Wrist Extension</td>
<td>116</td>
<td>30 (6-64)</td>
<td>60-70</td>
</tr>
<tr>
<td>Elbow Flexion</td>
<td>107</td>
<td>135</td>
<td>140-150</td>
</tr>
<tr>
<td>Elbow Extension</td>
<td>106</td>
<td>-27 (-51-10)</td>
<td>0-85</td>
</tr>
</tbody>
</table>

Further
• 6 DoF implementation.
• Augmenting EMG sensor.
• Going for full body Exoskeleton.
• Stabilization based on conservation of angular momentum.
• Optimizing the controls.

Traversing cam pin results in rotation.