CLAIMS

1. An upper limb assistive system, comprising:

a support member for supporting an upper limb of a subject;

an actuator coupled to the support member to move the support member; and

a computing module in signal communication with the actuator, the computing module comprising a processing unit; and a non-transitory media having media storing instructions readable by the processing unit, the media storing instructions that when executed by the processing unit, causes the processing unit to:

receive a first support position and a first support orientation of the support member in an actuator frame, the support member being coupled to the upper limb of the subject;

determine a shoulder position of the subject based on at least one anthropometric measurement of the subject;

based on the shoulder position of the subject, transform the first support position and the first support orientation in the actuator frame to a corresponding second support position and a corresponding second support orientation in a subject shoulder frame, wherein the subject shoulder frame corresponds to the shoulder position of the subject;

estimate a plurality of upper limb joint angles corresponding to a plurality of upper limb parts, based on the corresponding second support position and the corresponding second support orientation using a human inverse kinematics model corresponding to the subject; and

determine a gravity-compensated force on the support member based on the plurality of upper limb joint angles.

2. The upper limb assistive system as recited in claim 1, wherein the instructions further causes the processing unit to:

transform the first support position and the first support orientation in the actuator frame to a corresponding intermediate support position and a corresponding intermediate support orientation in a subject pelvis frame; and

based on the at least one anthropometric measurement and a sagittal plane in the subject pelvis frame, transform the intermediate support position and the intermediate support orientation in the subject pelvis frame to the corresponding second support position and the corresponding second support orientation in the subject shoulder frame.

3. The upper limb assistive system as recited in claim 2, wherein the instructions further causes the processing unit to:

form a first arc in the sagittal plane with a first center and a first anthropometric measurement as a first radius; and

form a second arc in the sagittal plane with a second center and a second anthropometric measurement as a second radius; and

determine the shoulder position based on an intersection of the first arc and the second arc in the sagittal plane.

4. The upper limb assistive system as recited in claim 3, wherein the first center is at a hip joint position of the subject, and wherein the first anthropometric measurement is a distance between the hip joint position and a shoulder of the subject, and wherein the second center is a projected elbow joint in the sagittal plane, and wherein the second

anthropometric measurement is a distance between the shoulder and the second center of the subject.

5. The upper limb assistive system as recited in any one of claims 1 to 4, wherein the subject shoulder frame is fixed relative to the actuator frame, wherein the plurality of upper limb joint angles comprises at least one shoulder angle and an elbow angle.

6. The upper limb assistive system as recited in any one of claims 1 to 5, wherein an elbow position and a wrist position of the subject corresponds respectively to the first support position and the first support orientation of the support member.

7. The upper limb assistive system as recited in any one of claims 1 to 6, wherein the first support position and the first support orientation correspond to a forearm position and a forearm orientation of the subject.

8. The upper limb assistive system as recited in any one of claims 1 to 7, wherein the actuator further comprises a plurality of linkage members operably coupled via a plurality of joints, wherein the instructions further causes the processing unit to: determine the first support position and the first support orientation of the support member based on a respective plurality of joint angles of the plurality of joints.

9. The upper limb assistive system as recited in any one of claims 7 to 8, wherein at least one of the plurality of joints is an active joint, and wherein at least one of the plurality of joints is a passive joint.

10. An upper limb assistive method, comprising:

receiving a first support position and a first support orientation of a support member in an actuator frame, the support member being coupled to an upper limb of a subject;

determining a shoulder position of the subject based on at least one anthropometric measurement of the subject;

based on the shoulder position of the subject, transforming the first support position and the first support orientation in the actuator frame to a corresponding second support position and a corresponding second support orientation in a subject shoulder frame, wherein the subject shoulder frame corresponds to the shoulder position of the subject;

estimating a plurality of upper limb joint angles corresponding to a plurality of upper limb parts, based on the corresponding second support position and the corresponding second support orientation using a human inverse kinematics model corresponding to the subject; and

determining a gravity-compensated force on the support member based on the plurality of upper limb joint angles.

11. The upper limb assistive method as recited in claim 10, further comprising:

transforming the first support position and the first support orientation in the actuator frame to a corresponding intermediate support position and a corresponding intermediate support orientation in a subject pelvis frame; and

based on the at least one anthropometric measurement and a sagittal plane in the subject pelvis frame, transforming the intermediate support position and the intermediate support orientation in the subject pelvis frame to the

corresponding second support position and the corresponding second support orientation in the subject shoulder frame.

12. The upper limb assistive method as recited in claim 11, further comprising:

forming a first arc in the sagittal plane with a first center and a first anthropometric measurement as a first radius;

forming a second arc in the sagittal plane with a second center and a second anthropometric measurement as a second radius; and

determining the shoulder position based on an intersection of the first arc and the second arc in the sagittal plane.

13. The upper limb assistive method as recited in claim 12, wherein the first center is at a hip joint position of the subject, and wherein the first anthropometric measurement is a distance between the first center and a shoulder of the subject, and wherein the second center is a projected elbow joint in the sagittal plane, and wherein the second anthropometric measurement is a distance between the second center and the shoulder of the subject.

14. The upper limb assistive method as recited in claim 13, wherein the subject shoulder frame is fixed relative to the actuator frame, wherein the plurality of upper limb joint angles comprises at least one shoulder angle and an elbow angle.

15. The upper limb assistive method as recited in any one of claims 11 to 14, wherein an elbow position and a wrist position of the subject corresponds respectively to the first support position and the first support orientation of the support member, and wherein

the first support position and the first support orientation correspond to a forearm position and a forearm orientation of the subject.