AN AUTOMATED HAND

FIELD

This invention relates to an automated hand. The invention also relates to a cover for an automated hand. The invention also relates to a wrist for an automated hand. The invention also relates to a wrist joint. The invention also relates to an assembly including a wrist joint and an automated hand.

BACKGROUND

Automated hands are commonly used as prosthetic hands, which may be used to grip objects, shake the hand of another person, and perform other tasks commonly carried out by human hands.

SUMMARY

An aspect of the invention is defined in the independent claim. Some optional features of the invention are defined in the dependent claims.

According to one disclosed example there is provided an automated hand comprising:

a. a palm;

b. a rigid mount in or on the palm;

c. a resiliently deformable sleeve located within the rigid mount, the resiliently deformable sleeve having a sleeve aperture therein; and

d. a connector located within the sleeve aperture, the connector having a digit extending therefrom, wherein the digit is moveable relative to the palm;

the automated hand being arranged such that the connector can rotate with respect to the mount when a force is applied to the digit extending therefrom.

In some disclosed examples, the arrangement is such that each connector can rotate in the plane of the palm.

In some disclosed examples, the arrangement is such that each connector can rotate in a plane normal to the plane of the palm.

In some disclosed examples, the arrangement is such that each connector can rotate about its longitudinal axis.

In some disclosed examples, the arrangement is such that each connector can translate when a force is applied to the digit extending therefrom.

In some disclosed examples, the arrangement is such that each connector can translate with three translational degrees of freedom.

In some disclosed examples, the automated hand is configured to absorb shocks applied longitudinally to the digits.

In some disclosed examples, the connector is part of a digit drive that drives flexion and/or extension of the digit.

In some disclosed examples, the connector comprises an actuator.

In some disclosed examples, the actuator comprises a motor.

In some disclosed examples, the connector is connected between an actuator and the digit.

In some disclosed examples, the automated hand comprises an actuator in the digit, the actuator driving flexion and/or extension of the digit.

In some disclosed examples, the actuator comprises a pivot between the connector and the rigid mount, the connector being rotatable with respect to the mount about the pivot.

In some disclosed examples, the pivot comprises one or more pairs of bearing surfaces, one of the bearing surfaces being on or coupled to the rigid mount and the other being on or coupled to the connector, wherein the bearing surfaces of each pair are in close proximity to each other.

In some disclosed examples, the resiliently deformable sleeve has one or more apertures formed therein and wherein one of the bearing surfaces of each pair is on a protrusion that protrudes at least partly through a respective one of the apertures.

In some disclosed examples, the automated hand further comprises a rigid sleeve between the connector and the resiliently deformable sleeve.

In some disclosed examples, the rigid sleeve is configured to couple the connector to the rigid mount.

In some disclosed examples, the rigid sleeve comprises one or more twist-lock features to twist lock to complementary twist lock features on a retainer that retains it with respect to the rigid mount.

In some disclosed examples, one of the bearing surfaces of each pair is provided on the rigid sleeve.

In some disclosed examples, the automated hand further comprises a seal between the connector and the rigid mount to prevent liquid from entering a sealed region within the automated hand.

In some disclosed examples, the seal is located near the pivot.

In some disclosed examples, the automated hand comprises:

one or more further rigid mounts attached to the palm;

one or more further resiliently deformable sleeves, each with a respective sleeve aperture therein, wherein each further resiliently deformable sleeve is located within a respective one of the one or more further rigid mounts; and

one or more further connectors, each located within a respective sleeve aperture, each further connector having a further digit extending therefrom;

wherein each further connector can rotate with respect to its respective rigid mount when a force is applied to the further digit extending therefrom.

In some disclosed examples, the rigid mounts are integral with each other.

In some disclosed examples, the rigid mounts are separate from each other.

In some disclosed examples, the rigid mount is configured to provide limits to the rotation of the connector with respect to the mount.

In some disclosed examples, an inner surface of the rigid mount within which the resiliently deformable sleeve sits is dimensioned to control the maximum lateral rotation of the connector about one or more axes.

In some disclosed examples, the automated hand further comprises a barrier around a portion of the connector that is not within the rigid mount, the barrier configured to limit lateral rotation of the connector about one or more axes.

In some disclosed examples, an inner surface of the rigid mount includes one or more rotation restraints to limit rotation of the connector about its longitudinal axis.

In some disclosed examples, each connector is coupled to the respective digit by an articulated joint.

In some disclosed examples, the resiliently deformable sleeve comprises an elastomer, rubber, silicone, or a polymer.

In some disclosed examples, the resiliently deformable sleeve comprises polyurethane or a hydrocarbon-, fluorocarbon- or silica-based elastomer.

In some disclosed examples, the resiliently deformable sleeve is a thermoset elastomer.

In some disclosed examples, the resiliently deformable sleeve is a thermoplastic material, such as a thermoplastic elastomer.

In some disclosed examples, the resiliently deformable sleeve is a thermoset rubber.

In some disclosed examples, the resiliently deformable sleeve comprises a foamed composition of one or more of the materials recited in the preceding paragraphs.

In some disclosed examples, the resiliently deformable sleeve comprises an alloy or blend of two or more of the materials recited in the preceding paragraphs.

In some disclosed examples, the resiliently deformable sleeve comprises a material with a DMTA damping factor of between about 0.05 and about 0.8 over a temperature range of about -20°C to about 100°C.

In some disclosed examples, the resiliently deformable sleeve comprises a material with a DMTA damping factor of between about 0.05 and about 0.5 over a temperature range of about -20°C to about 100°C.

In some disclosed examples, the automated hand comprises a material having a resilience of between about 20% and about 60%.

In some disclosed examples, the resiliently deformable sleeve comprises a material having a Shore A hardness of between about 10 and about 90.

In some disclosed examples, the resiliently deformable sleeve comprises a material having a Shore A hardness of between about 30 and about 60.

In some disclosed examples, the resiliently deformable sleeve comprises a material with a Shore A hardness of about 30.

In some disclosed examples, the resiliently deformable sleeve comprises a material having a Shore D hardness of between about 40 and about 90.

According to another disclosed example there is provided a touchscreen-compatible automated hand comprising:

a. a conductive member;

b. a digit; and

c. one or more conductive attachments;

wherein the one or more conductive attachments are configured to be attached to the digit to provide a conductive path from the exterior of the digit to the conductive member; and

wherein the automated hand is configured to allow operation of the touchscreen when the conductive path is electrically insulated from the body of a user of the automated hand.

According to another disclosed example there is provided a touchscreen-compatible automated hand comprising:

a. a conductive member;

b. a digit; and

c. one or more conductive attachments;

wherein the one or more conductive attachments are configured to be attached to the digit to provide a conductive path from the exterior of the digit to the conductive member, the conductive path being insulated from the body of a user of the automated hand in use.

In some disclosed examples, one or more of the conductive attachments comprises a polymer.

In some disclosed examples, the polymer is silicone.

In some disclosed examples, the one or more of the conductive attachments also comprises a conductive carbon additive.

In some disclosed examples, the conductive carbon additive comprises carbon nanotubes.

In some disclosed examples, the conductive member is a structural member of the automated hand.

In some disclosed examples, the conductive member is a structural member of the digit.

In some disclosed examples, the conductive member is part of a linkage of the digit.

In some disclosed examples, the one or more conductive attachments comprise a pad and link piece, the pad being located at the exterior of the digit in use and the link piece being in contact with the pad and the conductive member in use.

In some disclosed examples, the pad is the conductive attachment defined in any one of the preceding paragraphs.

In some disclosed examples, the link piece is a spring that is biased towards contact with the conductive member.

In some disclosed examples, the one or more conductive attachments comprise a conductive distal phalanx of the digit.

In some disclosed examples, the conductive member is mechanically coupled to the conductive distal phalanx.

In some disclosed examples, the conductive path is insulated from terminals of an actuator of the automated hand.

In some disclosed examples, the conductive path is insulated from a housing of the actuator.

In some disclosed examples, the conductive member and the one or more conductive attachments are configured to, upon one of the conductive attachments touching the touchscreen, cause a touch-sensing array in the touchscreen to sense a change in capacitance within a range indicative of a natural human finger touching the touchscreen.

In some disclosed examples, the conductive path terminates at the conductive member.

In some disclosed examples, the one or more conductive attachments are configured to be retrofit to an existing, non-touchscreen-compatible automated hand.

According to another disclosed example there is provided a method comprising:

attaching one or more conductive attachments to a digit of an automated hand; and

placing one of the one or more conductive attachments in contact with a conductive member of the automated hand;

wherein the one or more conductive attachments provide a conductive path from an exterior of the digit to the conductive member.

In some disclosed examples, the conductive member is a structural member of the automated hand.

In some disclosed examples, the conductive member is part of a linkage of the digit.

In some disclosed examples, one of the conductive attachments comprises a polymer.

In some disclosed examples, the one of the conductive attachments also comprises a conductive carbon additive.

In some disclosed examples, the conductive carbon additive comprises carbon nanotubes.

In some disclosed examples, attaching one or more conductive attachments to the digit comprises:

attaching a link piece to the digit; and

attaching a pad at the exterior of the digit and in contact with the link piece;

and wherein placing one of the one or more conductive attachments in contact with a conductive member of the automated hand comprises biasing the link piece towards contact with the conductive member.

In some disclosed examples, the method includes retrofitting the one or more conductive attachments to a non-touchscreen-compatible automated hand to produce a touchscreen-compatible automated hand.

In some disclosed examples, the method further comprises removing a non-conductive part of the non-touchscreen-compatible automated hand and replacing it with one or more of the conductive attachments.

According to another disclosed example there is provided an automated hand comprising:

a. a palm;

b. a digit extending from the palm; and

c. a worm drive configured to rotate the digit relative to the palm in use, wherein the worm drive includes a worm and a bearing configured to resist axial forces generated by the worm in both directions along the worm longitudinal axis.

In some disclosed examples, the bearing is placed between the worm and a motor that drives rotation of the worm.

In some disclosed examples, the bearing is a deep groove ball bearing.

In some disclosed examples, the worm is restrained against axial movement relative to the bearing.

In some disclosed examples, the automated hand comprises flanges secured to the worm, with one flange at each side of the bearing.

In some disclosed examples, one or more of the flanges are welded to the worm.

In some disclosed examples, the automated hand further comprises a two-part housing, wherein an outer race of the bearing is held between two parts of the housing.

In some disclosed examples, the worm drive further comprises a second bearing at the opposite side of the worm from the bearing.

In some disclosed examples, the second bearing is smaller than the bearing.

In some disclosed examples, the diameter of the second bearing is about two thirds of the diameter of the bearing or less.

In some disclosed examples, the diameter of the second bearing is about one half of the diameter of the bearing.

In some disclosed examples, the second bearing is configured to resist radial forces on the worm.

In some disclosed examples, the second bearing is configured to provide substantially no resistance to the axial forces generated by the worm.

In some disclosed examples, the second bearing is configured to be slidable with respect to the longitudinal axis of the worm.

According to another disclosed example there is provided a cover for an automated hand, the cover comprising:

a. a cover body including a knitted material ; and

b. a hand coupling on the cover body, the hand coupling configured to be secured to an automated hand.

In some disclosed examples, the knitted material is configured to have a low resistance to stretching over a first stretch range and a high resistance to stretching over a second stretch range, where the second range is higher than the first range.

In some disclosed examples, the resistance to stretching increases sharply between the first stretch range and the second stretch range.

In some disclosed examples, the cover body is configured to cover an articulated joint of the automated hand.

In some disclosed examples, the cover body is configured to cover a thumb joint of the automated hand.

In some disclosed examples, the cover body is configured to cover a joint between the automated hand and a wrist.

In some disclosed examples, the cover body is configured to maintain a substantially smooth surface during movement at the joint.

In some disclosed examples, the cover is configured to allow movement at the articulated joint over its full range of motion without significantly loading an actuator that drives movement at the articulated joint.

In some disclosed examples, the cover is configured to not back drive an actuator that drives movement at the articulated joint when stretched.

In some disclosed examples, the knitted material is knitted from elastic thread.

In some disclosed examples, the hand coupling is a shaped body having greater rigidity than the cover body material.

In some disclosed examples, the hand coupling is made of moulded plastic.

In some disclosed examples, the hand coupling at least partly encircles an edge of the cover.

In some disclosed examples, the hand coupling is configured to couple to the palm of the automated hand.

In some disclosed examples, the cover further comprises a wrist coupling configured to couple to a wrist that the automated hand is coupled to.

In some disclosed examples, the cover further comprises a thumb coupling configured to couple to a thumb of the automated hand.

In some disclosed examples, the hand coupling is configured to be sandwiched between shell pieces of the automated hand.

In some disclosed examples, the wrist coupling is configured to be retained in a groove that encircles the wrist.

In some disclosed examples, the cover further comprises one or more additional bodies of a material having greater rigidity than the cover body material to help maintain the shape of the cover.

In some disclosed examples, the additional bodies comprise one or more hoops that fully or mostly encircle a part of the cover.

In some disclosed examples, the additional bodies are made of moulded plastic.

In some disclosed examples, the cover body is configured to allow water to pass through it such that water can drain from a region between the automated hand and the cover.

In some disclosed examples, the cover body material is knitted with a sufficiently coarse knit to allow water to pass through the material.

In some disclosed examples, the cover body is formed by a 3D knitting process.

In some disclosed examples, the cover body comprises a plurality of regions having different properties from each other.

In some disclosed examples, the cover body comprises a thumb region that covers at least part of a thumb of the automated hand and a palm region that covers at least part of a palm of the automated hand.

In some disclosed examples, two or more of the regions have different stretch characteristics from each other.

In some disclosed examples, the thumb region is formed of a less stretchy material than the palm region.

In some disclosed examples, two or more of the regions have different coarsenesses from each other.

In some disclosed examples, the thumb region is formed of a coarser material than the material of the palm region.

In some disclosed examples, the plurality of regions includes a region that is not made of a knitted material.

In some disclosed examples, the thumb region is made of a knitted material and the palm region includes a woven material.

In some disclosed examples, the cover body has different stretch characteristics in different directions.

In some disclosed examples, the cover is configured to approximate the shape of the part of a natural human hand that corresponds to the part of the automated hand that is covered by the cover.

In some disclosed examples, the cover body is substantially free of corrugations in use.

In some disclosed examples, the cover further comprises one or more reinforced regions configured to lie over protruding features or user input features of the automated hand.

In some disclosed examples, the cover further comprises one or more visual indicators configured to lie over user input features of the automated hand.

In some disclosed examples, the cover further comprises one or more seams, wherein the seams are sewn, knitted, glued, or joined using bonding tape.

According to another disclosed example there is provided a cover for an automated hand, the cover comprising:

a. a cover body including a fabric material; and

b. a structural brace attached to the cover body and configured to support the cover body against external forces;

wherein the cover is configured to be secured to an automated hand.

In some disclosed examples, the structural brace is configured to support the cover body against collapse due to gravity.

In some disclosed examples, the cover body is configured to cover an articulated joint of the automated hand.

In some disclosed examples, the cover body is configured to cover a thumb joint of the automated hand.

In some disclosed examples, the cover body is configured to cover a joint between the automated hand and a wrist.

In some disclosed examples, the cover body is configured to maintain a substantially smooth surface during movement at the joint.

In some disclosed examples, the cover is configured to allow movement at the articulated joint over its full range of motion without significantly loading an actuator that drives movement at the articulated joint.

In some disclosed examples, the cover is configured to not back drive an actuator that drives movement at the articulated joint when stretched.

In some disclosed examples, the cover body includes a knitted material.

In some disclosed examples, the structural brace comprises a hand coupling configured to couple the cover to the automated hand.

In some disclosed examples, the hand coupling is made of moulded plastic.

In some disclosed examples, the hand coupling at least partly encircles an edge of the cover.

In some disclosed examples, the hand coupling is configured to couple to the palm of the automated hand.

In some disclosed examples, the structural brace comprises a wrist coupling configured to couple to a wrist that the automated hand is coupled to.

In some disclosed examples, the structural brace comprises a thumb coupling configured to couple to a thumb of the automated hand.

In some disclosed examples, the hand coupling is configured to be sandwiched between shell pieces of the automated hand.

In some disclosed examples, the wrist coupling is configured to be retained in a groove that encircles the wrist.

In some disclosed examples, the structural brace comprises one or more inward brace pieces located inward from the edges of the cover body to help maintain the shape of the cover.

In some disclosed examples, the inward braces comprise one or more hoops that fully or mostly encircle a part of the cover.

In some disclosed examples, the inward braces are made of moulded plastic.

In some disclosed examples, the wrist coupling and/or the thumb coupling are made of moulded plastic.

In some disclosed examples, the cover body is configured to allow water to pass through it such that water can drain from a region between the automated hand and the cover.

In some disclosed examples, the cover body includes a woven material.

In some disclosed examples, the cover is configured to approximate the shape of the part of a natural human hand that corresponds to the part of the automated hand that is covered by the cover.

In some disclosed examples, the structural brace is configured to maintain the shape of the cover when the cover is not on the automated hand.

In some disclosed examples, the cover body is substantially free of corrugations in use.

In some disclosed examples, the cover further comprises one or more reinforced regions configured to lie over protruding features or user input features of the automated hand.

In some disclosed examples, the cover further comprises one or more visual indicators configured to lie over user input features of the automated hand.

In some disclosed examples, the cover further comprises one or more seams, wherein the seams are sewn, knitted, glued, or joined using bonding tape.

According to another disclosed example there is provided an automated hand comprising:

a. a palm;

b. a thumb mounted to the palm of the hand, wherein the thumb is pivotally mounted to the palm at a first connection; and

c. an auxiliary support from an intermediate location along the thumb to a second connection on the palm.

In some disclosed examples, the second connection on the palm is spaced apart from the first connection.

In some disclosed examples, the first connection is at the base of the palm.

In some disclosed examples, the second connection is intermediate the base of the palm and the distal end of the palm.

In some disclosed examples, the intermediate location is at least 10% of the length of the thumb from an end of the thumb.

In some disclosed examples, the intermediate location is at least 25% of the length of the thumb from the end of the thumb.

In some disclosed examples, the thumb comprises two segments connected by an articulated joint.

In some disclosed examples, the intermediate location is near the articulated joint.

In some disclosed examples, the intermediate location is at the articulated joint.

In some disclosed examples, the intermediate location is distal of the articulated joint.

In some disclosed examples, the auxiliary support is flexible.

In some disclosed examples, the auxiliary support is a support arm.

In some disclosed examples, the support arm comprises a resilient material, for example a polymer.

In some disclosed examples, the second connection is a pivotal connection.

In some disclosed examples, the support arm is configured to connect to both sides of the thumb at the intermediate location.

In some disclosed examples, the support arm has a curved shape which can straighten under tension.

In some disclosed examples, a side of the support arm facing away from the base of the palm has a concave portion to assist gripping of objects.

In some disclosed examples, the support arm is configured such that it does not interfere with the palm or the thumb other than at the first and second connections as the thumb moves through its full range of motion.

In some disclosed examples, the auxiliary support is a cord.

In some disclosed examples, the thumb has a compliant portion between the first connection and the intermediate location.

In some disclosed examples, the first connection comprises a substantially rigid mount in or on the palm.

In some disclosed examples, the auxiliary support is frangible and wherein the thumb is connected to the palm via a safety pivot that allows the thumb to pivot freely in the extension direction upon breaking of the auxiliary support.

In some disclosed examples, the automated hand further comprises a catch configured to restrict pivoting of the thumb at the first connection when the thumb is under load.

According to another disclosed example there is provided an automated hand comprising:

a. a palm having a pivotal mount;

b. a digit pivotally mounted to the pivotal mount to pivot about a first axis, the digit being compliant at a compliance location distal of the pivotal mount; and

c. a catch configured to selectively restrict pivoting of the digit about the first axis when the digit complies at the compliance location under load.

In some disclosed examples, the digit is compliant about a second axis corresponding to a flexion-extension axis of the digit.

In some disclosed examples, the digit is a thumb.

In some disclosed examples, the first axis corresponds to an antepositioning-retropositioning axis of the thumb.

In some disclosed examples, the pivotal mount is substantially non-compliant about the second axis.

In some disclosed examples, the digit is disposed at or near a first side of the palm and wherein the catch is located between the digit and the first side of the palm.

In some disclosed examples, the catch includes a tooth attached to the digit and one or more recesses on the palm, wherein the tooth is driven towards the recess(es) when the digit complies at the compliance location.

In some disclosed examples, the tooth is biased away from the recess(es) when the digit is not under load.

In some disclosed examples, the load is a load in the extension direction of the digit.

In some disclosed examples, the digit comprises a compliant articulated joint at the compliance location.

In some disclosed examples, the catch is configured to restrict pivoting of the digit about the first axis when an external force is applied to the digit towards extension of the digit at the compliant articulated joint.

In some disclosed examples, the catch is configured to restrict pivoting of the digit about the first axis when a digit actuator drives the digit towards flexion of the digit at the compliant articulated joint.

In some disclosed examples, the catch includes a link arm that is coupled to a compliantly mounted gear, the compliantly mounted gear being mounted in a segment of the digit that is on the proximal side of the articulated joint and engaged with a gear on the distal side of the articulated joint.

In some disclosed examples, the gear on the distal side of the articulated joint is a drive gear that drives rotation of the digit at the articulated joint.

In some disclosed examples, the automated hand further comprises an actuator in the digit on the distal side of the articulated joint, the actuator being configured to drive the drive gear.

In some disclosed examples, the tooth is carried on the link arm.

In some disclosed examples, the bias is provided by a spring kinematically coupled to the link arm.

In some disclosed examples, the proximal portion of the digit comprises a compliant housing at the compliance location or another such compliance location.

According to another disclosed example there is provided an assembly comprising a wrist and an automated hand, the assembly further comprising:

a. a coupling tongue extending from the wrist or the automated hand, the coupling tongue having a distal portion and a proximal portion, the distal portion being wider than the proximal portion; and

b. a coupling clamp extending from the other one of the wrist and the automated hand, the coupling clamp configured to receive and clamp onto the coupling tongue to releasably couple the wrist to the automated hand.

In some disclosed examples, the coupling clamp comprises a clamp plate configured to be tightened onto the coupling tongue.

In some disclosed examples, the coupling clamp comprises one or more screw fasteners for tightening the clamp plate.

In some disclosed examples, clamping the coupling clamp onto the coupling tongue pulls the wrist and hand together.

In some disclosed examples, the assembly is configured such that the contact interface at which the coupling clamp and the coupling tongue contact each other when the coupling tongue is received in the coupling clamp is at an oblique angle to a longitudinal axis running through the wrist and the automated hand.

In some disclosed examples, wherein the coupling clamp and the coupling tongue have complementary faces configured to abut each other and restrict lateral movement of the hand with respect to the wrist.

In some disclosed examples, the coupling tongue is located within a pocket and wherein the coupling clamp is configured to fit snugly within the pocket such that the complementary faces include inner faces of the pocket and outer faces of the coupling clamp.

In some disclosed examples, the coupling tongue includes one or more ribs and wherein the coupling clamp includes one or more slots configured to fit snugly over the ribs such that the complementary faces include sides of the rib(s) and sides of the slot(s).

According to another disclosed example there is provided an automated hand assembly comprising:

a. an automated hand;

b. a wrist;

c. a releasable mechanical coupling for releasably mechanically coupling the wrist to the automated hand; and

d. a releasable electrical coupling for releasably electrically coupling the wrist to the automated hand;

wherein the releasable electrical coupling comprises a plurality of biased terminals on the automated hand or the wrist, each biased terminal being biased towards a complementary terminal on the other one of the automated hand and the wrist, each biased terminal being configured to electrically connect to the complementary terminal when the wrist is mechanically coupled to the automated hand.

In some disclosed examples, the biased terminals are spring loaded.

In some disclosed examples, the complementary terminals are pads.

In some disclosed examples, the pads are concave.

In some disclosed examples, the wrist comprises a cable, with the biased terminals or the complementary terminals being located at the end of the cable.

In some disclosed examples, the automated hand assembly further comprises a friction fit feature on the cable that configured to couple to a friction fit feature on the hand.

In some disclosed examples, the automated hand assembly further comprises a brace on the wrist, the brace configured to prevent electrical decoupling of the terminals when the cable and the hand are mechanically coupled.

In some disclosed examples, the wrist has a port formed in it to allow the cable to pass from one side of the wrist to the other.

In some disclosed examples, the automated hand assembly further comprises a rotary coupling for coupling the wrist to an arm socket, the rotary coupling configured to allow the wrist to rotate about a longitudinal axis of the arm socket.

According to another disclosed example there is provided a wrist for use with an automated hand, the wrist comprising:

a. a first coupling for coupling the wrist to an arm socket;

b. a second coupling for coupling the wrist to the automated hand;

c. a rotatable wrist joint between the first coupling and the second coupling, the wrist joint configured to rotate to allow the automated hand to flex or extend; and

d. a locking mechanism comprising a base and a locking plate configured to rotate relative to each other upon the rotation of the wrist joint, wherein the base has one or more recesses and the locking plate is selectively configurable between two states, a first state in which the locking plate is biased towards engagement with one of the one or more recesses of the base and a second state in which the locking plate is retained out of engagement with the recesses of the base;

wherein the locking mechanism is configured to restrict the rotation of the wrist joint when the locking plate is engaged with one of the one of more recesses of the base.

In some disclosed examples, the locking mechanism further includes a locking button configured to be pushed along a first axis to select the configuration of the locking plate, the first axis being transverse to the direction in which the locking plate moves to enter the recess(es).

In some disclosed examples, the first axis lies along the rotational axis of the rotatable wrist joint.

In some disclosed examples, the locking plate has a recess for receiving a pin coupled to a locking actuator, the recess having a sloped surface, the plate being moved away from engagement with the recess when the pin rides over the sloped surface.

In some disclosed examples, the wrist further comprises a spring configured to bias the plate towards engagement with the recess(es).

In some disclosed examples, the one or more recesses are a plurality of recesses arranged radially around the rotational axis of the rotatable wrist joint.

In some examples, the locking plate is configured to move directly towards the rotational axis of the rotatable wrist joint to engage with the recesses.

According to another disclosed example there is provided a wrist joint for use with an automated hand, the wrist joint comprising:

a. a rigid sleeve with an aperture formed therein, the aperture being non-circular in cross section;

b. a rigid axle extending through the aperture, the axle being non-circular in cross-section; and

c. one or more resiliently deformable pieces in the aperture between the rigid sleeve and the rigid axle;

wherein the rigid axle has a neutral orientation with respect to the rigid sleeve, and wherein the one or more resiliently deformable pieces return the rigid axle towards the neutral orientation after rotation away from the neutral orientation.

In some disclosed examples, the rigid axle has a non-planar face adjacent to at least one of the resiliently deformable pieces.

According to another disclosed example there is provided a wrist joint for use with an automated hand, the wrist joint comprising:

a. a rigid sleeve with an aperture formed therein, the aperture being non-circular in cross section;

b. a rigid axle extending through the aperture, the axle being non-circular in cross-section; and

c. one or more resiliently deformable pieces in the aperture between the rigid sleeve and the rigid axle;

wherein the rigid axle has a non-planar face adjacent at least one of the one or more resiliently deformable pieces, the non-planar face being shaped to provide a neutral orientation of the rigid axle with respect to the rigid sleeve, and wherein

the one or more resiliently deformable pieces return the rigid axle towards the neutral orientation after rotation away from the preferred neutral orientation.

In some disclosed examples, the non-planar face is concave.

In some disclosed examples, the non-planar face is configured to provide, for small deviations from the neutral orientation, a higher return torque towards the neutral orientation than a planar face would.

In some disclosed examples, the aperture in the rigid sleeve has a plurality of corners with a resiliently deformable piece in each corner.

In some disclosed examples, in cross section the perimeter of the aperture includes one or more part-circular arcs and one or more recesses; and each of the one or more recesses is configured to receive one of the one or more resiliently deformable pieces.

In some disclosed examples, in cross section the perimeter of the rigid axle includes one or more part-circular arcs and one or more recesses formed in it, wherein:

each recess of the rigid axle is configured to receive one of the one or more resiliently deformable pieces; and each of the one or more resiliently deformable pieces is held between one of the recesses of the aperture and one of the recesses of the rigid axle.

In some disclosed examples, the resiliently deformable pieces are elastomers or suitable polymers.

It is acknowledged that the terms “comprise”, “comprises” and “comprising” may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, these terms are intended to have an inclusive meaning – i.e., they will be taken to mean an inclusion of the listed components which the use directly references, and possibly also of other non-specified components or elements.

CLAIMS:

1. An automated hand comprising:

    a. a palm;

    b. a rigid mount in or on the palm;

    c. a resiliently deformable sleeve located within the rigid mount, the resiliently deformable sleeve having a sleeve aperture therein; and

    d. a connector located within the sleeve aperture, the connector having a digit extending therefrom, wherein the digit is moveable relative to the palm;

    the automated hand being arranged such that the connector can rotate with respect to the mount when a force is applied to the digit extending therefrom.

2. The automated hand of claim 1 wherein the arrangement is such that the connector can rotate in the plane of the palm.

3. The automated hand of claim 1 or claim 2 wherein the arrangement is such that the connector can rotate in a plane normal to the plane of the palm.

4. The automated hand of any one of claims 1 to 3 wherein the arrangement is such that the connector can rotate about its longitudinal axis.

5. The automated hand of any one of claims 1 to 4 wherein the arrangement is such that the connector can translate when a force is applied to the digit extending therefrom.

6. The automated hand of claim 5 wherein the arrangement is such that the connector can translate with three translational degrees of freedom.

7. The automated hand of any one of claims 1 to 6 wherein the connector is part of a digit drive that drives flexion and/or extension of the digit.

8. The automated hand of claim 7 wherein the connector comprises an actuator.

9. The automated hand of claim 8 wherein the actuator comprises a motor.

10. The automated hand of claim 7 wherein the connector is connected between an actuator and the digit.

11. The automated hand of any one of claims 1 to 6 comprising an actuator in the digit, the actuator driving flexion and/or extension of the digit.

12. The automated hand of any one of claims 1 to 11 comprising a pivot between the connector and the rigid mount, the connector being rotatable with respect to the mount about the pivot.

13. The automated hand of claim 12 wherein the pivot comprises one or more pairs of bearing surfaces, one of the bearing surfaces being on or coupled to the rigid mount and the other being on or coupled to the connector, wherein the bearing surfaces of each pair are in close proximity to each other.

14. The automated hand of claim 13 wherein the resiliently deformable sleeve has one or more apertures formed therein and wherein one of the bearing surfaces of each pair is on a protrusion that protrudes at least partly through a respective one of the apertures.

15. The automated hand of any one of claims 1 to 14 further comprising a rigid sleeve between the connector and the resiliently deformable sleeve.

16. The automated hand of claim 15 wherein the rigid sleeve is configured to couple the connector to the rigid mount.

17. The automated hand of claim 16 wherein the rigid sleeve comprises one or more twist-lock features to twist lock to complementary twist lock features on a retainer that retains it with respect to the rigid mount.

18. The automated hand of any one of claims 15 to 17 when dependent on claim 13 or 14 wherein one of the bearing surfaces of each pair is provided on the rigid sleeve.

19. The automated hand of any one of claims 1 to 18 further comprising a seal between the connector and the rigid mount to prevent liquid from entering a sealed region within the automated hand.

20. The automated hand of claim 19 when dependent on any one of claims 12 to 14 or 18 wherein the seal is located near the pivot.

21. The automated hand of any one of claims 1 to 20 comprising:

one or more further rigid mounts attached to the palm;

one or more further resiliently deformable sleeves, each with a respective sleeve aperture therein, wherein each further resiliently deformable sleeve is located within a respective one of the one or more further rigid mounts; and

one or more further connectors, each located within a respective sleeve aperture, each further connector having a further digit extending therefrom;

wherein each further connector can rotate with respect to its respective rigid mount when a force is applied to the further digit extending therefrom.

22. The automated hand of claim 21 wherein the rigid mounts are integral with each other.

23. The automated hand of claim 21 wherein the rigid mounts are separate from each other.

24. The automated hand of any one of claims 1 to 20 wherein the rigid mount is configured to provide limits to the rotation of the connector with respect to the mount.

25. The automated hand of claim 24 wherein an inner surface of the rigid mount within which the resiliently deformable sleeve sits is dimensioned to control the maximum lateral rotation of the connector about one or more axes.

26. The automated hand of claim 24 or 25 wherein an inner surface of the rigid mount includes one or more rotation restraints to limit rotation of the connector about its longitudinal axis.

27. The automated hand of any one of claims 1 to 26 wherein each connector is coupled to the respective digit by an articulated joint.

28. The automated hand of any one of claims 1 to 27 wherein the resiliently deformable sleeve comprises an elastomer, rubber, silicone, or a polymer.

29. The automated hand of any one of claims 1 to 28 wherein the resiliently deformable sleeve comprises a material with a DMTA damping factor of between about 0.05 and about 0.8 over a temperature range of about -20°C to about 100°C.