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(54) **GRIPPER COMPRISING A RESETABLE SNAP-BAND AND METHOD OF USE**

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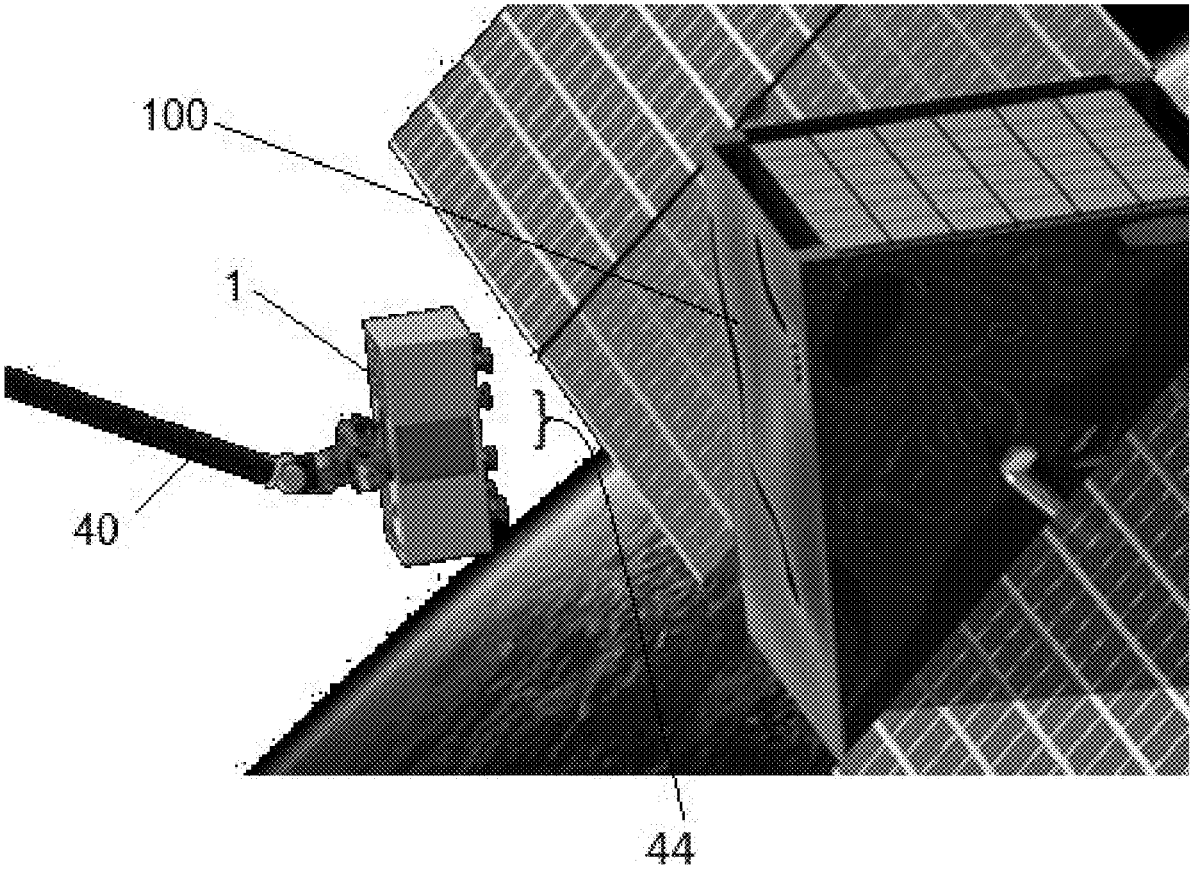
(57) **ABSTRACT**

Two objects can be connected, e.g., in space, by maneuvering a gripper proximate a target which may be in space, commanding the snap-band controller to move the snap-band into its open position, maneuvering the gripper to a further position closer to the target to where the controllable snap-band, when closed, at least partially encircles the target, and commanding the snap-band controller to move the controllable snap-band into its closed position to at least partially encircle and capture the target. The gripper comprises a controllable snap-band comprising a selectable open position and closed position which is disposed about an external surface of a housing.



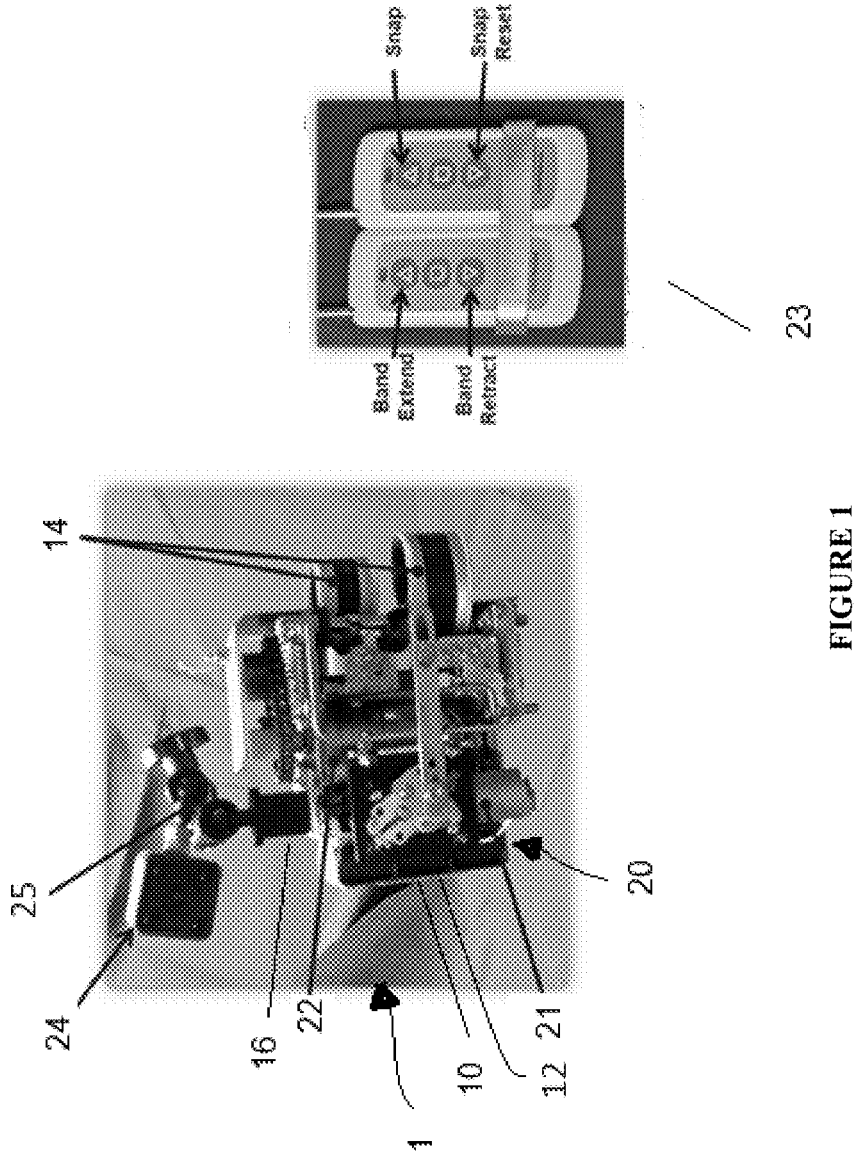

Snap
Snap Reset
Band Extend
Band Retract
23
14
25
24
16
22
1
10
12
21
20

FIGURE 1

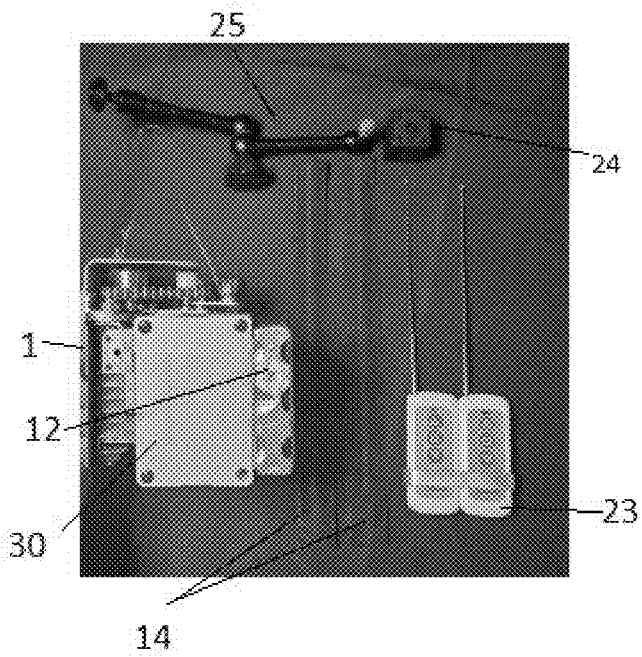


FIGURE 2

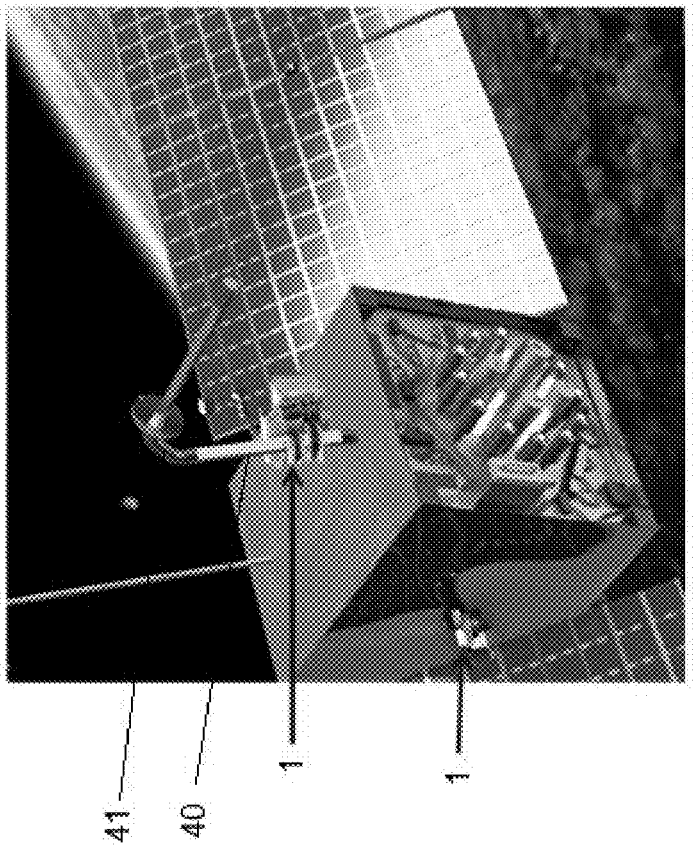


FIGURE 3

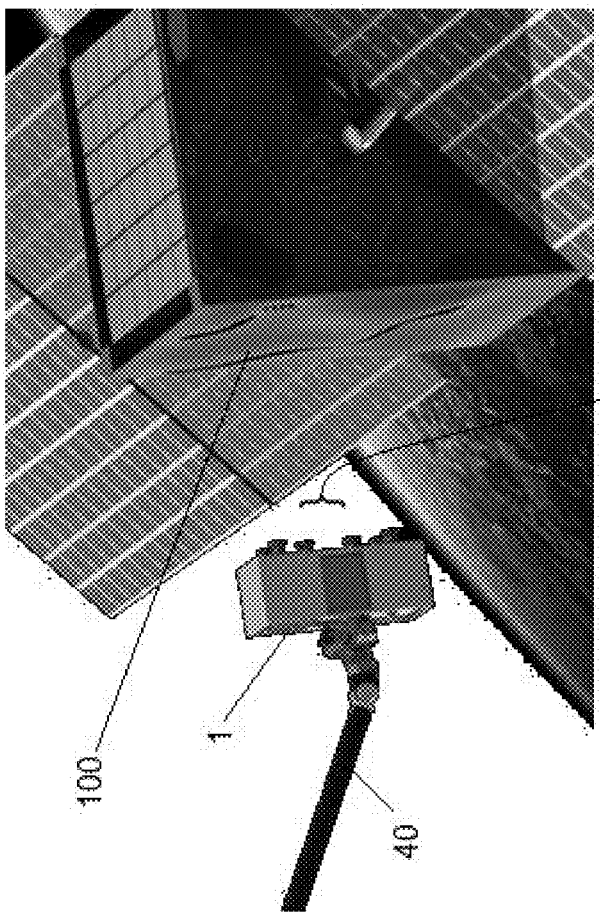


FIGURE 4

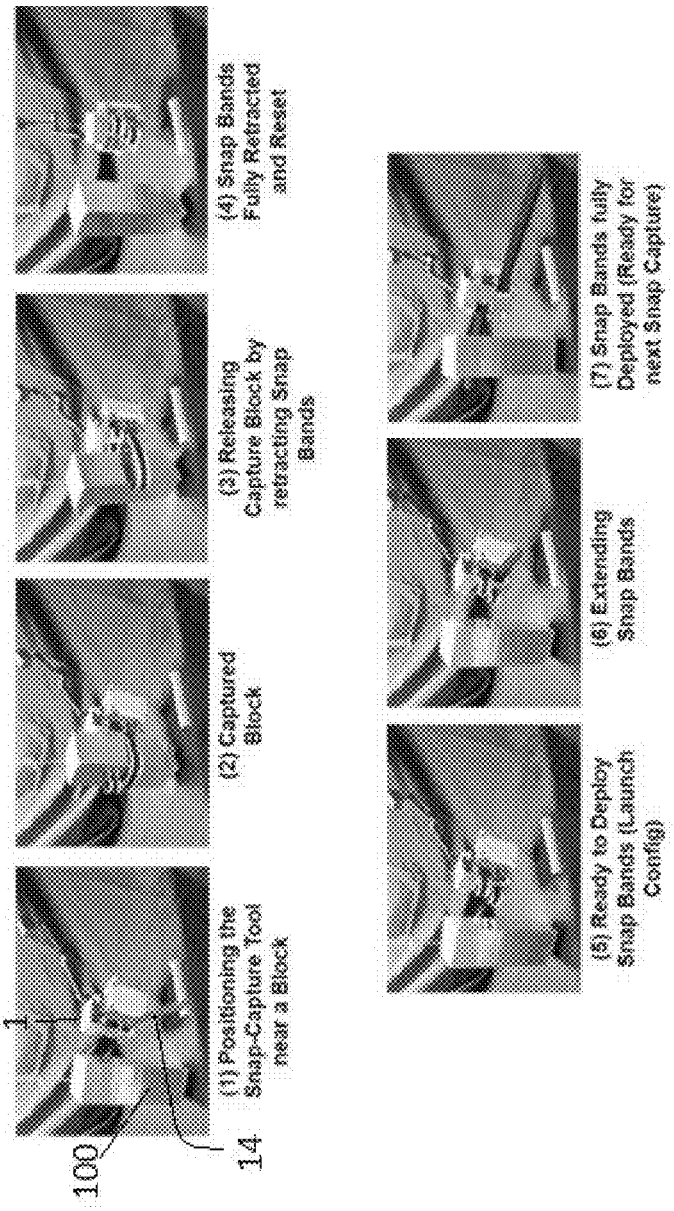

100
14
1
(1) Positioning the Snap-Capture Tool near a Block
(2) Captured Block
(3) Releasing Capture Block by retracting Snap Bands
(4) Snap Bands Fully Retracted and Reset
(5) Ready to Deploy Snap Bands (Launch Config)
(6) Extending Snap Bands
(7) Snap Bands fully Deployed (Ready for next Snap Capture)

FIGURE 5

GRIPPER COMPRISING A RESETABLE SNAP-BAND AND METHOD OF USE

[0001] This application claims priority through U.S. Provisional Application 63/410,808 filed on Sep. 28, 2022.

BACKGROUND

[0002] The claimed invention addresses a needed means for a gripping device to rapidly grip around a target object, including an irregularly shaped target and a sporadically moving target, such as in-space debris.

FIGURES

[0003] Various figures are included herein which illustrate aspects of embodiments of the disclosed inventions.

[0004] FIG. **1** is a cutaway view in partial perspective of an exemplary embodiment with an exemplary remote controller;

[0005] FIG. **2** is a further view in partial perspective of an exemplary embodiment;

[0006] FIG. **3** is a view in partial perspective of an exemplary embodiment;

[0007] FIG. **4** is a view in partial perspective of an exemplary embodiment; and

[0008] FIG. **5** is a series of views in partial perspective of an exemplary embodiment as used.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0009] As used herein, a "target" is a relatively stationary or sporadically/randomly moving object to which a device equipped with gripper **1** needs to attach, even if the target comprises an irregular shape. Gripper **1** also reduces potential damage to a soft or non-rigid target during attachment and reduces the chance that a target will be knocked away during a gripping operation.

[0010] In a first embodiment, referring generally to FIG. **1**, gripper **1** comprises housing **10**; one or more power supplies **12** (FIG. **2**) typically disposed at least partially within housing **10**; one or more snap-bands **14**, e.g., a plurality, disposed about an external surface of housing **10**, each snap-band **14** comprising a selectable open position, e.g., a position when snap-band **14** is in an externally extended, linear configuration extending from an external surface of housing **15**, and closed position, e.g., when snap-band **14** is an externally coiled or circumferential configuration; and snap-band controller **20** disposed at least partially within housing **10** where snap-band controller **20** is operatively connected to power supply **12** and is operatively connected to snap-bands **14** and is operative to selectively move snap-band **14** between it open position and its closed position

[0011] Generally, snap-band **14** comprises a bi-stable metal spring strip which may be coated, sleeved, and/or covered in cloth, plastic, or another coating, or the like, or a combination thereof. The coat, sleeve, or cover may comprise an organic component or an inorganic component. Referring additionally to FIG. **5**, snap-band **14** has a first stable state as a substantially straight metal strip with a convex curve across its width and a second stable state where snap-band **14** is curved, e.g., into one or more, e.g., two, encircling hoops. When snap-band **14** is in its straight state and stable, its convex curve is forced into a partially flattened state and an unconstrained portion of snap-band **14** will attempt rapidly coil into one or more hoops and wrap around target **100** (FIG. **4**) to grip it. Bending of snap-band **14** is an elastic deformation and snap-band **14** can be "reset" by forcing it to bend elastically from one stable structure to the other.

[0012] In embodiments, snap-band **14** is selectively detachable from snap-band controller **20**, from housing **10**, or from both snap-band controller **20** and housing **10**.

[0013] Snap-band **14** may be configured to accommodate encircling an irregular shape, e.g., structurally link to target **100** and in-space debris. Typically, snap-band **14** comprises a rapid closing reaction time, e.g., a closing reaction time which is sufficiently fast to prevent a touched target **100** from reactively moving away. This reaction time is typically around or less than one second for a snap-band length of 12 inches or less.

[0014] In embodiments, gripper **1** is configured to accommodate sporadic/random motion between housing **15** and a moving target **100**, e.g., a tumbling target.

[0015] A predetermined set of payload electronics **30** (FIG. **2**) may be disposed at least partially within or otherwise attached to housing **10**. Moreover, electro-magnet **44** (FIG. **4**), which can be an permanent electro-magnet, may be disposed at least partially exposed through housing **10**, e.g., to create a more rigid, secondary attachment to target **100**.

[0016] Snap-band controller **20** is operative to selectively move snap-bands **14** between their open position, e.g., an extended position, and their closed position, e.g., a "snapped," retracted, or coiled position. Snap-band controller **20** is also operative to selectively move snap-band **14** between an externally coiled position (potentially gripping an object such as target **100** (FIG. **4**)) to an internally coiled position or to an open position to release gripper **1** from target **100**.

[0017] In embodiments, gripper **1** further includes a snap-band extension guide that reshapes snap-band **14** so that it can then be commanded to extend in the open position from its closed position. The snap-band extension guide effectively pushes on a center width of snap-band **14** to force it from its closed shape into its open shape as it is commanded to be extended. In embodiments, still referring to FIG. **1**, snap-band controller **20** further comprises one or more snap actuation motors or actuators **21**, one or more snap-band motors or actuators **22** operatively connected to snap-band **14**, and a separate control interface **23**. It will be understood by one of ordinary skill in this art that control interface **23** can be a remote or local human interface device, a computerized controller, or the like, or a combination thereof.

[0018] Gripper **1** may further comprise support junction **16** disposed about a surface of housing **10**. In these embodiments, arm **25** may be connected to support junction **16** and one or more devices such as camera **24**. In addition, in embodiments snap-band **14** further comprise additional components such as electronics or reflective surfaces and gripper **1** may act as a payload when separated from gripper **1** and left behind on target **100**.

[0019] In embodiments, gripper **1** may be attached to a robotic or support arm and act as a robotic end effector. In other embodiments, gripper **1** may be attached to self-propelled device such as a satellite bus.

[0020] In the operation of exemplary methods, referring back to FIG. **1** and generally to FIG. **5**, two objects may be connected, e.g., in microgravity in-space environments, by maneuvering gripper **1** proximate target **100** where gripper **1** is as described above. Snap-band controller **20** is commanded, e.g., initially, to move snap-band **14** into its open position, e.g., by using snap-band motor **22** which is operatively connected to snap-band **14** and control interface **23**, and gripper **1** maneuvered to a further position closer to target **100** to where snap-band **14**, when closed or retracted, will at least partially encircle or otherwise coil about target **100**. A further command may issue, e.g., using controller interface **23**, commanding snap-band controller **20** to move, e.g., "snap," snap-band **14** into its closed position to at least partially encircle and capture target **100**, e.g., using one or more snap actuation motors or actuators **21**.

[0021] In embodiments, the command to move the snap-band into its closed position causes snap-band **14** to quickly coil about target **100**, e.g., take around one second or less for a length of snap-band **14** of around 12 inches or less.

[0022] With respect to a fully or partially engaged gripper which is gripping target **100**, snap-band controller **20** may be commanded to move snap-band **14** into its open position which will retract snap-band **14** from captured target **100** and release gripper **1** from the captured target **100**, e.g., by using snap-band motor **22** operatively connected to snap-band **14** and controller interface **23**.

[0023] A released gripper **1** may be commanded to capture a new target by maneuvering gripper **1** proximate the new target, which may be in space; commanding snap-band controller **20** to move snap-band **14** into its open position, if it is not already in its open position; maneuvering gripper **1** to a further position closer to the new target to where snap-band **14**, when closed, at least partially encircles the new target; and commanding snap-band controller **20** to move snap-band **14** into its closed position to at least partially encircle the new target.

[0024] In embodiments, an engaged gripper **1** may detach snap-band **14** from target **100**, leaving the detached snap-band **14** on the captured target by detaching snap-band **14** from housing **10** and/or from snap-band controller **20**. Gripper **1** may be supplied with a replacement snap-band **14** once snap-band **14** has detached from gripper **1**.

[0025] Where housing **10** further comprises support junction **16** and support arm **40** (FIG. **3**) operatively connected to support junction **16**, support arm **40** may be used to maneuver gripper **1** proximate target **100**. In addition, peripheral **41** (FIG. **3**), e.g., a camera, may be operatively connected to support arm **40** and used as an aid in maneuvering gripper **1** proximate target **100**.

[0026] In embodiments, one or more snap-bands **14** are primarily positioned by motorized rollers into and between the open state, the externally coiled state (after being "snapped"), and the internally coiled state. Typically, snap-band **14** is "snapped" by one or more actuators **21** which forcibly flatten a section of the curved width of an open snap-band **14** causing the external section of snap-band **14** to coil. A guide may be present and used to forcibly curve the flat width of a coiled snap-band **14** which causes it to be straighten during snap-band extension to the open position.

[0027] The foregoing disclosure and description of the inventions are illustrative and explanatory. Various changes in the size, shape, and materials, as well as in the details of the illustrative construction and/or an illustrative method may be made without departing from the spirit of the invention.

1. A gripper, comprising:
a) a housing;
b) a power supply disposed at least partially within the housing;
c) a controllable snap-band comprising a selectable, controllable open position and selectable, controllable closed position, the controllable snap-band disposed about and extending from an external surface of the housing; and
d) a snap-band controller disposed at least partially within the housing, the snap-band controller operatively connected to the power supply and operatively connected to the controllable snap-band, the snap-band controller operative to selectively move the snap-band between the snap-band's open position and the snap-band's closed position.

2. The gripper of claim **1**, wherein the controllable snap-band is selectively detachable from the snap-band controller and from the housing.

3. The gripper of claim **1**, wherein the controllable snap-band comprises a cover.

4. The gripper of claim **1**, wherein the controllable snap-band is configured to accommodate encircling an irregular shape.

5. The gripper of claim **1**, wherein the gripper is configured to accommodate sporadic motion between the housing and a moving target.

6. The gripper of claim **1**, wherein the controllable snap-band comprises a closing reaction time of around one second or less to prevent a touched target from reactively moving away.

7. The gripper of claim **1**, wherein the controllable snap-band comprises a plurality of controllable snap-bands.

8. The gripper of claim **1**, further comprising a predetermined set of payload electronics (**30**) disposed at least partially within the housing.

9. The gripper of claim **1**, further comprising an electromagnet (**44**) disposed at least partially exposed through the housing.

10. The gripper of claim **1**, wherein the snap-band controller further comprises:
a) a snap actuation motor;
b) a snap-band motor or actuator operatively connected to the controllable snap-band; and
c) a control interface.

11. The gripper of claim **1**, further comprising a support junction disposed about a surface of the housing.

12. The gripper of claim **11**, further comprising:
a) an arm connected to the support junction; and
b) a camera connected to the arm.

13. A method of connecting two objects in space, comprising:
a) maneuvering a gripper proximate a target, the gripper comprising:
i) a housing;
ii) a power supply disposed at least partially within the housing;
iii) a controllable snap-band comprising a selectable open position and closed position, the controllable snap-band disposed about an external surface of the housing; and

iv) a snap-band controller disposed at least partially within the housing, the snap-band controller operatively connected to the power supply and operatively connected to the controllable snap-band, the snap-band controller operative to selectively move the snap-band between the open position and the closed position;

b) commanding the snap-band controller to move the snap-band into its open position;

c) maneuvering the gripper to a further position closer to the target to where the controllable snap-band, when closed, at least partially encircles the target; and

d) commanding the snap-band controller to move the controllable snap-band into its closed position to at least partially encircle and capture the target.

14. The method of claim **13**, wherein the command to move the controllable snap-band into its closed position causes the snap-band to coil about the target in no more than one second.

15. The method of claim **13**, further comprising:

a) commanding the snap-band controller to move the controllable snap-band into its open position; and

b) retracting the controllable snap-band from the captured target to release the gripper from the captured target.

16. The method of claim **15**, further comprising commanding a released gripper to capture a new target by:

a) maneuvering the gripper proximate the new target;

b) commanding the snap-band controller to move the controllable snap-band into its open position, if it is not already in its open position;

c) maneuvering the gripper to a further position closer to the new target to where the controllable snap-band, when closed, at least partially encircles the new target; and

d) commanding the snap-band controller to move the controllable snap-band into its closed position to at least partially encircle the new target.

17. The method of claim **13**, further comprising leaving the controllable snap-band on the captured target by detaching the controllable snap-band from the housing and from the snap-band controller.

18. The method of claim **17**, wherein the snap-band controller comprises a snap-band actuator and detaching the controllable snap-band from the gripper comprises disengaging the snap-band actuator so that an external pull-off force between the target and the gripper causes the snap-band to be fully separated from the gripper while the snap-band remains wrapped around the target.

19. The method of claim **17**, further comprising supplying the gripper with a replacement controllable snap-band once the controllable snap-band has detached from the gripper.

20. The method of claim **13**, wherein the housing further comprises a support disposed about an external surface of the housing, the support comprising a support arm, the method further comprising:

a) attaching the support arm to the support; and

b) using the support to maneuver the gripper proximate the target.

* * * * *