Operator’s Manual

The Human Integrated Gripping Device

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Important Safety Instructions

Beware; the handling of this device outside of its intended use can lead to serious injury. Always follow all of the protocols set forth in this operator’s manual when using the Human Integrated Gripping Device.

The Human Integrated Gripping Device is a new and innovative tool aimed at helping those who have lost the ability to grip on to objects in their hands. The device works off a series of highly intricate mechanics intertwined within a glove system with a release mechanism. The mechanics allow the user to clamp down onto the object while the release mechanism allows for release of the mechanics from the object and the glove offers some protection to the user’s hand. Although the Human Integrated Gripping Device is incredibly capable and useful, the operator should always take the utmost precautions when handling the device.

To begin gripping objects, the user must insert his hand within the Human Integrated Gripping Device. Never place hands within the device with the right hand; the glove is only intended for the left hand. Also, never place any other object inside of the Human Integrated Gripping Device. It is highly recommended that the user not use and other glove lining on the glove other then the one provided. The operator should also not place hands into the object while the hand is wet. Once the glove is on the operator there are some additional procedures.

The glove does not protect against electrical charges and in fact will conduct them due to the mechanical devices within. Therefore, never handle any open power lines, open electrical outlets, or any other type of open electrical source while using the Human Integrated Gripping Device. The glove does not protect against acids or any other hazardous materials and should not be used in their handling. In addition to these concerns, the user should avoid getting the Human Integrated Gripping Device wet. This can lead to eventual corrosion and failure of the device after a prolonged period of time. Therefore, avoid the use of the Human Integrated Gripping Device in the rain, shower, underwater or any other situation that presents water.

When using the device, the user shall place the Human Integrated Gripping Device around the object of interest. They shall then close their hand or clamp down the mechanics with their free hand as to grip the object. The thumb of the glove shall then be hooked to the Velcro portion of the glove to form a tight fit. The operator is now free to use the object as desired. Once gripping is complete, unhook the thumb from the Velcro portion of the glove. User must then remove the object from the glove. Pull on the release mechanism strings in the following order: green, blue, and red. This shall be done to both sides of the glove. Once the glove has been opened into a straight line, the user may then remove the glove. These instructions should be followed closely to avoid injury while using the Human Integrated Gripping Device.
Parts and Accessories

Mechanics

Figure 1. Ratchet, Pawl, Spring and Casing

Release System

Figure 2. Tubular Plastic with strings

Figure 3. String Release System

Glove Interface

Figure 4. Stainless Steel Ring

Figure 5. Glove with Velcro hook
Features

The Human Integrated Gripping Device combines a variety of interesting and unusual features to achieve the goal of gripping. The most integral aspect of the glove is the ratchet mechanism. These ratchet and pawl pieces, which are shown above, click in place as the user grips down on the object. This enables the glove to latch onto objects of varying sizes with ease and strength. The mechanics are also attached to stainless steel rings which not only provide a rigid attachment for contact with the hand but also serve as contact points for the object to remain in place within the hand.

Another intriguing feature is the integrated tubular release mechanism. These plastic tubes run in parallel with the mechanics on each side of the mitten. They house the string releases for each of the pawls. Not only do they provide a minimal friction surface for ease of use but they also establish a protective environment for the release mechanism. The release mechanism itself is an innovative tool with quick response using minimal force.

The overall device has some incredible features. For one, it provides a user with minimal to no hand strength the ability to grip objects that they once could not. It does this through its ratcheting mechanics, string releases, and Velcro hooking grip. The glove provides a comfortable feel for the user as well as a secure grip with the use of the Velcro hook. The glove is also highly corrosive resistance with its gold plating mechanics. Finally, the minuscule size of the device makes it efficient while the stainless steel construction makes it highly durable and reliable. All these features allow the Human Integrated Gripping Device to be one of the simplest yet effective products available.
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1 Introduction

1.1 Overview

The main concept behind the design of the Human Integrated gripping Device is using a ratchet wheel that allows for motion in one direction and is restricted from moving in the opposing direction by the pawl that is lodged into the wheel. This is shown in the figure below.

![Ratchet Mechanism Basics](image)

**Figure 6.** Ratchet Mechanism Basics

The ratchet concept was extended to be used in a full mechanism that would run parallel to the hand. The mechanism consists of two units, one on each side of the hand. Each unit contains ratchet wheels at the knuckles of the hand with pawls and rigid extensions attached to each wheel. As the rigid extensions are forced down by the gripping motion, the pawl locked the position in place and maintained the grip. All these components are part of the mechanics subunit discussed below.

To control for the release of the mechanics, the release mechanism was created. Once the gripping position is no longer needed, the ratchet wheels can be allowed to retract in the opposing direction if the pawl contact can be removed. This is done by using a string system through tubular supports that led to each pawl. By pulling on the strings, one removes the pawls from the ratchet wheel and allows the hand to go back into the relaxed position. The tension on the strings comes from pulling on the string release at the glove interface pulling on the pawls to which the other ends of the strings are attached.

The final aspect of the design is the user interface. The user has complete control of the above mention mechanisms through an easy to use, tight fitting glove. An inner glove houses all the mechanics and string systems. It also contains rings that are rigidly attached to the mechanics at each segments joint of the hand for both the pinky and index finger. These rings act as the contact point for which the user exerts minimal force to achieve the gripping position. A top layer glove is also present to protect the workings of the Human Integrated Gripping Device as well as provide an aesthetic appeal to the device.
Ratchet Mechanics

The majority of the work done by the Human Integrated Gripping Device is accomplished through the use of the ratchet and pawl mechanics. Each ratchet wheel allows motion in only one direction as the pawls prevent movement in the opposing direction. So as the user grips down on an object, the mechanics freely move into a gripping motion. The pawls are maintained in place by springs made of spring metal which allows for a tight fit to the ratchet wheel but still has forgiveness to bend backwards and free the contacts for release. (Fig. 7) All the above mention parts are laser cut from stainless steel which is then gold plated for optimal corrosion resistance. These mechanics run on each side of the left hand where interlocking pawl/ratchet combos are located at each joint. The ratchets are then extended to each other via segments of stainless steel acting as arms. These two parallel mechanisms are encased in gold plated stainless steel casings and resemble thin fingers running alongside the hand. The figures below demonstrated all the above mentioned parts. (Fig. 8)

Figure 7. Ratchet, Pawl, and Spring of one joint segment
Release Mechanism

Once gripping of an object is no longer desired, the pawls can be made to retract from the contact points with the ratchet wheels. This is achieved by pulling against the pawls at their respective string attachments and pushing the pawls back against the springs. As the pawl is rotated back, the ratchet wheel is no longer held in place and can easily manipulate itself back into the relaxed position with minimal effort. The strings are attached to holes at the top of each pawl. These strings are made of Kevlar, which provides superior tensile properties as well as fatigue and cut resistance. Plastic tubular casings are then implemented around each of the strings for protection and also as a means of providing a practically friction free surface for ease of pulling on the strings. (Fig. 9) All 6 strings meet at the top of the hand where they are tied into the release mechanism. This mechanism consists of an individual string release system (Fig. 10). The strings attach to each side of the glove and are in complete relaxation while gripping is occurring. Once gripping is complete, the strings are pulled by the user. As a result, the strings are forced into tension and are maintained in that state. The strings act on the pawls and retract them from the ratchets causing the hand to be free from the gripping position.
For optimal control of the mechanics and the release mechanism, a highly integrated user interface is needed. A highly durable yet flexible glove provides the best option for doing such a task. The interface actually consists of two glove layers. The first layer is a durable work glove to which the mechanics can be attached to. The ratchets are put in place in accordance to the sizing of the user’s hands (custom fit) and are then secured on by sewing 20lb. fishing line around each segment. Custom rings are then attached at each arm segment of the mechanics. This rings act as points of contact for which force from the hand can be exerted on the mechanics to allow for the gripping position to take form. The rings are made out of stainless steel 314 which has been bent then welded to appropriate fitting. Each ring is secured on to the interior glove using the fishing line as well. Finally, the tubular casings of the release mechanism are glued together on each individual side and run through the interior of the rings. These tubes are also secured to the glove with the fishing line to minimize movement.
The inner glove is then protected by an outer glove which takes the form of a mitten. The mitten not only protects the inner mechanics of the Human Integrated Gripping Device but it also provides an aesthetic appeal to the device. The mitten is secured tightly to the inner glove by sewing them in conjunction so that a tight fitting interface is maintained. Next, the strings from the release mechanism are brought out to the posterior portion of the hand, where it attaches to the outer glove. The individual strings are sewed into the outer mitten for ease of use by the user. Finally, the Velcro hook is attached to the thumb and Velcro lining is placed on the outer portion of the fingers, where the thumb will attach to form a tight fitting grip.

Figure 13. Outer Glove
1.2 Instructions

**Step 1.** Place left hand inside of the Human Integrated Gripping Device with the assistance of the right hand or someone else. Ensure that the glove is tightly on and fingers are in appropriate sections.

![Figure 14. Putting on the glove](image-url)
Step 2. Place the glove around the object that one wishes to grasp.

Figure 15. Grasping on to an object
Step 3. Close the Human Integrated Gripping Device onto the object of interest. The may be done using the left hand to the best of one’s ability. The ratchets can be more firmly gripped by clasping down on both sides of the mitten.

Figure 16. Tightening the grip on an object

Figure 17. Gripping position of the glove
Step 4. Hook the thumb of the Human Integrated Gripping Device to the top of the Velcro layered finger section of the mitten. Grasp the hook on as tightly as possible for firmest grip desired.

Figure 18. Connection the thumb portion of the glove

Figure 19. Putting on the glove
**Step 5.** Use the grasped object as desired until gripping is no longer desired.

*Figure 20.* Using an object with the assistance of the Human Integrated Gripping Device
Step 6. To stop gripping, start by removing the hook from the thumb off the mitten. Remove the object being gripped with opposing hand or placing it down on firm surface.

Figure 21. Removing the thumb off the glove

Figure 22. Removing object from the Human Integrated Gripping Device
Step 7. Pull on the release strings on the right side of the hand first. Pull the strings in the following order: green, blue, red. The mechanics will naturally open up one at a time with minimal force outwards while pulling on the string. (Note: if mechanics do not release properly, please check Troubleshooting for appropriate actions)

Figure 23. Releasing the right side of the glove

Figure 24. Releasing the right side of the glove with extension
**Step 8.** Next, pull on the release strings on the left side of the hand. Pull the strings in the following order: green, blue, red. The mechanics will naturally open up one at a time with minimal force outwards while pulling on the string. (Note: if mechanics do not release properly, please check Troubleshooting for appropriate actions)

![Figure 25](image1.png)

**Figure 25.** Releasing the left side of the glove

![Figure 26](image2.png)

**Figure 26.** Releasing the left side of the glove with extension
Step 9. Once the mechanics are in a straight line running parallel with the user’s fingers, remove the glove from the left hand and store the Human Integrated Gripping Device for later use.

Figure 27. Glove in the inline straight position

Figure 28. Removing the glove
2 Maintenance

2.1
In order to maintain the Human Integrated Gripping Device in a fully functional state, the user needs to be aware of the conditions that may have an adverse effect on the functionality of the device.

2.2 Ratchets

In order to keep the ratchets (Fig 29) fully functional, a number of factors need to be taken into consideration. Firstly, since the ratchets are made of metal, it is important to keep them in a cool, dry environment in order to prevent corrosion. Subjecting the ratchets and other metallic portions of the device to excessive moisture, will increase the rate of corrosion and will reduce the effectiveness of the device. For this reason it is important that the user avoids submerging the device in water.

![Figure 29. Ratchets With Outer Casing Attached.](image)

It is also important to avoid getting debris such as dirt, mud, sand, and any other solid particles inside of the device where they may have a chance to disrupt the motion of the ratchets. Solid particles such as the ones mentioned above can become a problem to the normal operation of the device if they were to enter into the ratchets casing. This would cause the ratchets to jam and thereby reduce the effectiveness of the device as a whole.
2.3 Pawls & Springs

The pawls and the springs are two of the most important aspects of the system. These two units lock in place and release the ratchets. As with the ratchets, the pawls and springs are made of metal so a few of the same rules apply. It is important to keep them in a cool, dry environment in order to prevent corrosion. Subjecting the pawls and springs to excessive moisture will increase the rate of corrosion and will reduce the effectiveness of the device. For this reason it is important that the user avoids submerging the device in water. Figure 30 shows an image of the pawls and springs.

Figure 30. Image Showing Pawls And Springs.
It is also important to avoid getting debris such as dirt, mud, sand, and any other solid particles inside of the device where they may have a chance to disrupt the motion of the ratchets. Solid particles such as the ones mentioned above can become a problem to the normal operation of the device if they were to enter into the casing. This could possibly cause the pawls and springs to jam and thereby hinder the locking or releasing of the ratchets, or both.
2.4 Rings

The rings provide rigid attachment of the ratchets to the glove so that the movement of the user’s hand inside of the glove will be able to have the appropriate effect on the ratchets attached to the outside of the glove. Once again, these units are made of metal so the same concepts apply. It is important to keep them in a cool, dry environment in order to prevent corrosion. Subjecting the rings to excessive moisture will increase the rate of corrosion and will reduce the effectiveness of the device. For this reason it is important that the user avoids submerging the device in water. Figure 32 shows an image of the rings used in the system.

![Figure 32. Rings](image)

The user should also be aware that unnecessary pulling of the rings at each joint should be avoided because this could loosen the threaded connection between the ring and the ratchet casing or the ring and the glove either of which would cause the device to function below its potential.
2.5 Strings & Tubing

The strings allow for the user to release the device. Pulling the strings pulls the pawls backwards which consequently disengages the ratchets making them free to return to the open position. The strings are run through flexible plastic tubing. In order for these components to function optimally, the user should prevent the strings from coming into contact with sharp materials that may cut the string or cause any damage to them. Figure 33 shows an image of the tubing. The user should also avoid the loosening of the knots in the strings where they are attached to the small ring at the wrist area of the glove. It is also recommended that the strings and tubing be kept away from all flames.

Figure 33. Tubing for Strings.

Figure 34. Picture Showing Release Strings on Device
2.6 Inner Glove

The inner glove is the part of the device to which all the other components are attached. These include the ratchets, the strings, tubings, rings, and outer glove. Since this can be looked at as the framework of the device, it is most important that this portion of the device be maintained properly. In order to keep the inner glove in tact it is recommended that the device not be used around fire or any type of small or large flames because the glove is not flame resistant. The user should also avoid contact with sharp or jagged materials that may be able to cut or otherwise injure the glove adversely alter the functionality of the components attached to it.

One should also avoid getting the glove wet as the moisture can transfer to the metallic parts inside and cause corrosion.

Figure 35. Picture Showing the Inner Glove with Attached Components.
2.7 Outer Glove

It is important that the outer glove be protected since it covers all the internal moving parts from the outside. In order to keep the glove in tact it is recommended that the device not be used around fire or any type of small or large flames because the glove is not flame resistant. The user should also avoid contact with sharp or jagged materials that may be able to cut or otherwise injure the glove and expose the inner working parts.

One should also avoid getting the glove wet as the moisture can transfer to the metallic parts inside and cause corrosion.
2.8 Velcro

The Velcro portion of the device is used to secure the grip once the hand is in the desired position. As with the outer glove, in order to keep the Velcro components in tact it is recommended that the device not be used around fire or any type of small or large flame because the Velcro is not flame resistant. The user should also avoid contact with sharp or jagged materials that may be able to cut or otherwise injure the Velcro area and affect its functionality.

Figure 37. Picture of Glove Showing Velcro Component.
2.9 Overall Device

Not only is it important to make sure that each individual component of the device is maintained but it is also important that the device as a whole unit be maintained because protecting the device as a whole offers protection to each component individually. Figure 37 shows a picture of the device fully assembled and ready for use.

Figure 37. Device As Seen By User.

In order to keep the device and its components fully functional, a few different things need to be taken into consideration when using the device. Firstly, since the ratchets, pawls, rings, and springs are made of metal, it is important to keep the device in a cool, dry environment in order to prevent corrosion of its metallic parts. Subjecting the device to excessive moisture, will increase the rate of corrosion and will reduce the
effectiveness of the device. For this reason it is important that the user avoids submerging the device in water.

It is also important to avoid getting debris such as dirt, mud, sand, and any other solid particles inside of the device where they may have a chance to disrupt the motion of the ratchets. Solid particles such as the ones mentioned above can become a problem to the normal operation of the device if they were to enter into the casing. This would cause the device to jam and thereby reduce its effectiveness.

The unnecessary pulling of the device at each joint should be avoided because this could loosen the threaded connection between the ring and the ratchet casing or the ring and the glove either of which would cause the device to function below its potential.

In order for the device to function optimally, the user should prevent the strings from coming into contact with sharp materials that may cut the string or cause any damage to them. The user should also avoid situations in which the loosening of the knots in the strings could occur where they are attached to the small ring at the wrist area of the glove.

It is strongly recommended that the device be kept away from all flames and sources of moisture. In order to increase the longevity of the materials and components it is also recommended that the device be used clear of all sharp and jagged materials that may have the potential to injure the device or any of its components.

The device should be handled with care so as to not cause damage to any of the internal parts that are not visible by the user. If any of the components of this device were to become damaged or non-functional please refer to the Troubleshooting section of this manual.

Working with the device around electricity is also advised against. This has not only the potential to harm the device but also may cause injury to the user of the device. This could also start a fire which could cause serious injury to the user.
3 Technical Description

This section will outline each component of the Human Integrated Gripping Device. Below is a block diagram outlining the makeup of the device. Each component will be explained in a logical progression, starting from the inside layer of the glove to the very outer components.

Figure 38. Block Diagram of the Components of the Human Integrated Gripping Device
The following outline explains the order in which the components will be described. The headings of each subtopic explained are a component of this outline. If at any point the user gets lost, please refer to this outline to reorient oneself.

I. Inside Glove
   1. Index Finger Ratchet Mechanism
      a. Ratchets
      b. Pawls
      c. Rivets
      d. Springs
      e. Covers
      f. Sewed Support
   2. Pinky Finger Ratchet Mechanism
      a. Ratchets
      b. Pawls
      c. Rivets
      d. Springs
      e. Covers
      f. Sewed Support
   3. Ring Supports
      a. Rings
      b. Sewed Supports
   4. Release Mechanism
      a. Tubing
      b. String
      c. Sewed Support
      d. Tape/Glue

II. Outer Glove
   1. Release Strings
      a. Color Code
   2. Release Holes
   3. Release String Rings
   4. Velcro
      a. Thumb
      b. Posterior Velcro
I.1. Inside Glove, Index Finger Ratchet Mechanism

Before the inner workings of the ratchet mechanism is explained, Fig. 39 shows a picture of the completed index ratchet mechanism so the user has an idea of what is being referred to and what the final product looks like. Each component of this system is explained in more detail in the following sections.

Figure 39. a) Completed Index Ratchet Mechanism, b) Completed Mechanism Attached to Inner Glove

The ratchets are the basic core of this device; without them, the device will not perform. The individual ratchets can be seen below in Fig. 40. Both the CAD drawings and the actual manufactured pieces are shown. There are two types of ratchet designs. This is necessary for the different segments of the ratchet mechanism to fit together properly. The ratchet design labeled “c” in Fig. 40 is the ratchet located at the tip of the finger, which corresponds to the ratchet labeled “3” in Fig. 41. The ratchet design labeled “d” in Fig. 40 is used for every other segment of the mechanism and corresponds to the ratchets labeled “1” and “2” in Fig. 41. The only difference between the ratchet mechanism located on the index finger and that of the pinky side is ratchet number “1” in Fig. 41. On the index finger side, the arm of this ratchet was elongated to compensate for the length of the index finger. The CAD drawing for this specific ratchet is that seen in Fig. 3a.

Figure 40. Individual Ratchets
Figure 41 shows the inside of the ratchet mechanism (if the covers were removed from the ratchet shown in Fig. 39). The location of the individual ratchets as described for Fig. 40 is much clearer by looking at Fig. 41.

![Figure 41. Inside of Ratchet Mechanism (Before Covers are in Place)](image_url)

The ratchets function by allowing motion to proceed in the direction indicated in Fig. 4; the user is able to close his hand, but once closed, the hand is locked into position. This is possible because the teeth on the ratchet, combined with the pawl, restrict any movement in the opposite direction. (The pawl will be explained in the proceeding section.) With this understanding of the ratchets, we now move on to the pawls.
I.1.b. Inside Glove, Index Finger Ratchet Mechanism, Pawls.

As important as the ratchets are, this device would not work without the pawls. An individual pawl appears as shown in Fig. 42a below. Figure 42b shows the pawls in their proper locations within the mechanism.

![a) Individual Pawls, b) Pawls in Position](image)

As explained before, the user is able to close his hand freely. But, any force applied in the opposite direction is opposed by the notch of the pawl against the tooth of the ratchet. An enlarged image of the pawl/ratchet interface can be seen in Fig. 43. Please note that once the cover is in place, the spring that is overlapping the pawl in Fig. 43 would be flush with the edge of the pawl.
In order for the user to be able to release his grip position, the top of the pawls must be pulled in the direction indicated in Fig. 43. This disengages the pawl/ratchet connection and allows free motion of the ratchets once again. The release mechanism will be described in further detail shortly.
I.1.c. Inside Glove, Index Finger Ratchet Mechanism, Rivets.

Up until now, the ratchets and the pawls have been demonstrated as a complete unit with no regard to how these segments are joined together. This is where the rivets come into play. The rivets serve as pivot points for the ratchets and pawls and as stationary supports for the springs. There are three different size rivets; large, medium, and small. Referring to Fig. 44, the large rivets were used in location 1, the medium in location 2, and the two small rivets in location 3. The dimensions of each rivet can be seen in Table 1.

![Figure 44. 1) Large Rivet, 2) Medium Rivet, 3) Medium Rivets](image)

Table 1. Rivet Dimensions in Inches

<table>
<thead>
<tr>
<th>Rivet Size</th>
<th>Outer Diameter</th>
<th>Inner Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>.124</td>
<td>.06</td>
</tr>
<tr>
<td>Medium</td>
<td>.156</td>
<td>.06</td>
</tr>
<tr>
<td>Large</td>
<td>.186</td>
<td>.125</td>
</tr>
</tbody>
</table>

The mechanism which ensures that the pawl stays in contact with the ratchet is the spring. This can be seen in Fig. 44. As mentioned previously, when the covers are in place, the spring is flush with the edge of the pawl instead of overlapping as seen here. Not only does the spring maintain pawl/ratchet contact, it also allows the pawl to spring back into position after it has been pulled back for release. Individual springs before being placed into the ratchet mechanism can be seen in the figure below.

![Individual Springs](image)

**Figure 45.** Individual Springs
I.I.e. Inside Glove, Index Finger Ratchet Mechanism, Covers.

Once all the components are in place and the system resembles Fig. 42, the covers are put into place. These not only provide protection for the moving parts and the user, but they also keep the pawl, spring, and ratchet in line. Once the covers are in place, the completed ratchet mechanism looks like Fig. 40a. The individual covers before being placed on the ratchet mechanism can be seen in the figure below.

Figure 46. Covers for Ratchet Mechanism

With the ratchet mechanism complete it is then attached to the inner glove. The rings are attached first, which is described shortly. To attach the actual ratchet mechanism to the glove, the ends of each system were sewed down. This can be seen in Fig. 47 below.

![Attached Ratchet Mechanism](image)

Figure 47. Attached Ratchet Mechanism


A picture of the completed pinky finger ratchet mechanism can be seen below in Fig. 48.

![Completed Pinky Finger Ratchet Mechanism](image)

Figure 48. Completed Pinky Finger Ratchet Mechanism
Every description stated in the preceding sections applies to the pinky side ratchet mechanism; only one factor distinguishes the pinky side from the index side. As is obvious, the pinky finger is much smaller than the index finger. This necessitates different size mechanism for each side of the hand. To accomplish this, the ratchet labeled “1” in Fig. 42 was elongated for the index side and shortened for the pinky side. Again, the CAD drawing for the elongated piece is seen in Fig. 41a. The ratchet on the left side of Fig. 41b is the CAD drawing for the parallel part in the pinky mechanism. Other than this one difference, both ratchet mechanisms work off the same principles and thus will not be repeated in this section.

I.3.a. Inside Glove, Ring Supports, Rings.

To attach each completed ratchet mechanism to the inside glove, ring supports were used. This consists of a series of three rings, becoming progressively smaller as the tip of the finger is approached, which surround the ratchet mechanism and the glove. These rings can be seen in Fig. 49 before they are placed on the glove. The rings for the index finger are larger than those for the pinky finger to allow room for a larger circumference finger.

![Figure 49. Ring Supports Standing Alone: a) Index Side b) Pinky Side](image)
Figure 50 displays how the rings are placed over the ratchets and the inner glove.

![Figure 50. Ring Supports in Place over Ratchets and Inner Glove](image)

After being made, about 1cm of the ring’s circumference was hammered against a flat surface. The created a more flush fit with the surface of the ratchets and thus a more secure attachment for the system as a whole.

Not only do the rings provide support for the ratchet mechanism and keep everything aligned and attached, but they also aid in the closing of the ratchets. As the user closes his hand, the portions of the rings on the anterior side of the hand give the ratchets a solid surface to push against and thus aid in the ratchets’ contraction. This dual purpose is a great benefit of the ring design.

**I.3.b. Inside Glove, Ring Supports, Sewed Supports.**

To attach the rings to the inner glove, small regions were sewn around the ring attaching it to the glove. Approximately five of these spots were sewn per ring; two directly around the ratchet to secure its placement and three more distributed evenly around the remaining perimeter.

The release mechanism was mentioned briefly in the preceding sections but will now be explored in more detail. Once again, in order for the user to be able to open his hand, the pawls must be pulled backwards to disengage the ratchet tooth/pawl contact point. This is where the release mechanism comes into play. This system is compromised of three tubes per ratchet mechanism (one tube per pawl) and thus six tubes all together. These tubes can be seen below in Fig. 51 before they are attached to the inner glove.

Figure 51. Tubing used for Release Mechanism


Within each tube runs one Kevlar string, again totaling three strings per ratchet mechanism and six strings all together. The end of each string is tied to a pawl. As the user pulls the other end of the string, the pawl is pulled backwards and the ratchet is released allowing a full range of motion. Each pawl must be released separately and thus each joint is straightened individually. Figure 52 shows the entire release mechanism with each corresponding part labeled.

The tubing of the release mechanism is attached to the inner glove in several ways as to prevent shifting of the tubes which could result in decreased effectiveness of the system. One such way the tubes are attached is by sewed supports similar to that of the ring supports. Multiple locations along the length of the tubing are stitched to the inner glove, encompassing all three tubes per release mechanism. This helps keep all the tubes not only bundled but also in the correct position for optimal functionality. These sewed supports can be seen labeled in Fig. 52.


In addition to the sewed supports, several spots along the tube bundles were both duct taped and gorilla glued together. This provides extra security and assurance that the tubing will remain in the correct position. These spots can be seen labeled in Fig. 52.
II.1. Outer Glove, Release Strings.

Up to this point, the inner layer of the Human Integrated Gripping Device has been explored. This layer is where all the mechanics are located and form the core of the device. Now the outer glove will be explored. It is here that the user interface portion of the release mechanism is located and this will be the focus of discussion in the proceeding sections.


The user interface of the release mechanism is composed of six strings; three strings for the index finger ratchet mechanism and three strings for the pinky finger ratchet mechanism. Because these two sides function in exactly the same way, the index finger side will be focused on. A general picture of the user interface can be seen below in Fig. 53.

![Figure 53. User Interface of Release Mechanism](image)

Each string in the release mechanism is attached to its own pawl. Because of this, the strings are color coded and the same color code applies to each side of the hand. Table 2 outlines this color code and associates each string color to a pawl number as labeled in Fig. 54 below.
Table 2. String Color and its Corresponding Pawl

<table>
<thead>
<tr>
<th>String Color</th>
<th>Corresponding Pawl from Fig. 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magenta</td>
<td>3</td>
</tr>
<tr>
<td>Blue</td>
<td>2</td>
</tr>
<tr>
<td>Green</td>
<td>1</td>
</tr>
</tbody>
</table>
II.2. Outer Glove, Release Holes.

The gateways from the inner glove to the outer glove are the release holes. These are two holes located on either side of the outer glove which allow the Kevlar strings from the inner release mechanism to come through to the outer glove. One such hole can be seen in Fig. 55 below.

![Figure 55. Release Hole](image)


In order for the release strings to be secured down to the outer glove and not just dangling around, two rubber rings are attached approximately two inches away from the release holes, towards the wrist. These rings are attached by sewing supports similar to those encountered many times before. The release strings are subsequently tied to these rings forming a closed loop and preventing any dangling strings that could act as a hazard to the user and the device. Figure 56 indicates these release string rings.

![Figure 56. Release String Rings](image)
II.4.a. Outer Glove, Velcro, Thumb.

As the user closes his hand, the fingers are locked into position using the ratchet mechanism. In a natural grip, the thumb would then come over the top of the fingers, securing the grip and strengthening it. Because of this, added support was added to the outer glove to accommodate the thumb. To the thumb was added the hook portion of Velcro. This can be seen below in Fig. 57
II.4.b. Outer Glove, Velcro, Posterior Velcro.

The corresponding Velcro to the thumb is located on the posterior side of the fingers. A large area is covered giving the thumb a large contact region. This is helpful when the user grabs various size objects as the placement of the thumb will be varied with respect to the object size and shape. This Velcro can be seen below in Fig. 58.
Figure 58. Velcro on Posterior Side of Fingers
4 Trouble Shooting

The Human Integrated Gripping Device is a highly intricate tool aimed at helping individuals perform everyday tasks they previously could not. It does this through a series of mechanisms that help simulate the human ability of grasping objects. Although it is completely functional and sound, one may encounter problems when using the device. This section provides detailed instructions on what to do for a variety of different problems. Please use this as an initial resource when attempting to fix any problems associated with the Human Integrated Gripping Device. The table of contents below will help narrow your search to find the appropriate solution for your problem. If a problem cannot be solved, please contact the Biomedical Engineering Department at the University of Connecticut.
• **Putting on the Human Integrated Gripping Device**

- When using the Human Integrated Gripping Device, make sure to follow the procedure set forth in the Introduction section 1.2 of this Operator’s Manual (Page 11). This will eliminate most problems that occur when attempting to put on the glove.

- The user should **only** be using the **left hand**. The glove is specifically made for use with the left hand and will not fit nor function on the right hand.

- For problems with a tight fitting glove or difficulty in putting on the glove on one’s own, the help of another person may be needed to assist in putting on the Human Integrated Gripping Device.

- The Human Integrated Gripping Device is **custom fit** for the intended user. If you are not the intended user, the glove will not fit. If a glove is desired for a different user, please contact the University of Connecticut for further details on obtaining an appropriately sized glove.

- If the glove does not fit the intended user, please contact the Biomedical Engineering office at the University of Connecticut for resizing.

![Putting on glove](image)

**Figure 58.** Putting on glove
Taking off the Human Integrated Gripping Device

- When using the Human Integrated Gripping Device, make sure to follow the procedure set forth in the Introduction section 1.2 of this Operator’s Manual (Page 11). This will eliminate most problems that occur when attempting to put on the glove.

- The user should only be using the **left hand**. The glove is specifically made for use with the left hand and will not fit nor function on the right hand.

- For problems with a tight fitting glove or difficulty in putting on the glove on one’s own, the help of another person may be needed to assist in putting on the Human Integrated Gripping Device.

- The Human Integrated Gripping Device is **custom fit** for the intended user. If you are not the intended user, the glove will not fit. If a glove is desired for a different user, please contact the University of Connecticut for further details on obtaining an appropriately sized glove.

- If the glove does not fit the intended user, please contact the Biomedical Engineering office at the University of Connecticut for resizing.

- Be sure to have all the ratchets in the unlocked position shown below. This position is seen when the glove is in a complete straight line. Pull on all the strings and open up the Human Integrated Gripping Device until this position is achieved. If problems with ratchets and releases occur look below at the release mechanism trouble shooting.

![Inline Release Position of glove](image.png)

**Figure 59.** Inline Release Position of glove
- The thumb should be unhooked from its gripping position **before** attempting to remove the glove.

![Image](image1.png)

**Figure 60.** Removing thumb from glove

- If the user’s hand becomes stuck within the glove even after the ratchets have been released and the glove is in a straight line, attempt to pull on the index and pinky side fingers of the glove. By pulling on the rings lining each of these sections, one can pry the fingers loose. If this does not work, user may have to cut open the exterior glove on each side of the hand and manually move the rings directly or remove the rings to free the hand. *(Note: One should never force their hand into the Human Integrated Gripping Device so as to avoid problems such as this.)*

![Image](image2.png)

**Figure 61.** Removing glove
• Releasing the Human Integrated Gripping Device

- When using the Human Integrated Gripping Device, make sure to follow the procedure set forth in the Introduction section 1.2 of this Operator’s Manual (Page 11). This will eliminate most problems that occur when attempting to put on the glove.

- The user should only be using the left hand. The glove is specifically made for use with the left hand and will not fit nor function on the right hand.

- For problems with placing enough tension on the strings, the help of another person may be needed to assist in pulling on the Human Integrated Gripping Device release mechanism.

- The Human Integrated Gripping Device is custom fit for the intended user. If you are not the intended user, the glove will not fit. If a glove is desired for a different user, please contact the University of Connecticut for further details on obtaining an appropriately sized glove.

- If the glove does not fit the intended user, please contact the Biomedical Engineering office at the University of Connecticut for resizing.

- The ratchets should release to a straight line position as shown below. The ratchets return to this position naturally when the release mechanism is pulled though minimal external force is needed. If the user can not provide enough force by opening the hand while pulling the release mechanism, obtain the assistance of someone else to open the glove as the releases are being pulled.

Figure 62. Inline Release Position of glove
- If the ratchets of the Human Integrated Gripping Device will not release, one can pull on the individual pawls from the outside of the glove. There are three pawls running along each side of the hand. The general location of them is given by red dots on the glove. The user should feel for the tops of these pawls (feels like small round metal sections depicted below) and pull on them back towards the wrist. This will allow for the ratchets to release open.

![Pawl release locations](image)

**Figure 63.** Pawl release locations

- In the event that a string breaks off from the secured location of the glove, there are several options. One, attempt to reattach the string to the secured location if the string is still on the outside of the glove. If the string has broken on the inside, one can remove the outer glove by unttying all the release mechanism strings, unstitching the outer glove from the inner glove, removing the outer glove, and retying the broken string. All steps should then be followed in reverse to place the outer glove back on and tie the release mechanism strings back on. The user can also contact the Biomedical Engineering office at the University of Connecticut for further assistance.

![String release mechanism attachments](image)

**Figure 64.** String release mechanism attachments
Forming a tight grip with the Human Integrated Gripping Device

- When using the Human Integrated Gripping Device, make sure to follow the procedure set forth in the Introduction section 1.2 of this Operator’s Manual (Page 11). This will eliminate most problems that occur when attempting to put on the glove.

- The user should only be using the left hand. The glove is specifically made for use with the left hand and will not fit nor function on the right hand.

- The Human Integrated Gripping Device is custom fit for the intended user. If you are not the intended user, the glove will not fit nor will it be able to form a tight grip. If a glove is desired for a different user, please contact the University of Connecticut for further details on obtaining an appropriately sized glove.

- For problems with tightly hooking the thumb onto the Velcro of the back hand, the help of another person may be needed to assist pulling on the thumb hook of the Human Integrated Gripping Device so that an appropriate grip can be formed.

![Figure 65. Positioning the thumb in the gripping position](image)
For a tight grip to be formed, the ratchets of the Human Integrated Gripping Device need to be closed as much as possible so that a tight fit is made with the object being held. This may require additional force by the opposite hand to grasp down the ratchets onto the object as shown below or the help of someone to do the same. To close the ratchets further, place your hands around your fingers on each of the hand as to cup the index side and then the pinky side. Push down onto the object on both of these sides and listen for the clicking of the ratchets. Do this on all segments of your fingers for each side.

Figure 66. Ratcheting the glove for a tighter fit using other hand

The Human Integrated Gripping Device is intended for the gripping of cylindrical, small objects and other similar objects. If the object being handled is too large as to prevent attachment of the thumb to the Velcro or oddly shaped, then the Human Integrated Gripping Device may not be able to assist in gripping.
• Fixing the mechanics of the Human Integrated Gripping Device

- When using the Human Integrated Gripping Device, make sure to follow the procedure set forth in the Introduction section 1.2 of this Operator’s Manual (Page 11). This will eliminate most problems that occur when attempting to put on the glove.

- If the mechanics are not opening up, please see section: Releasing the Human Integrated Gripping Device in the Trouble Shooting portion of this Operator’s Manual.

- Problems in closing the mechanics:
  - If the ratchets of the mechanics are continually moving without holding in place, first check to ensure that the release mechanism strings are not being pulled. Next, check the individual pawl systems of the mechanics as described above in the section: Releasing the Human Integrated Gripping Device. If the pawls are freely moving with no struggle, then the spring has either worn out, corroded, or fell out and needs to be replaced. This would have to be done at the University of Connecticut. If the pawls do not move under any amount of force, then the pawls are either stuck or corroded and need to be inspected at the University of Connecticut.

  - If the ratchets of the mechanics are not moving no matter what force or are only moving in the closing direction and not the opening direction, then the string release mechanism has been compromised or the pawl/ratchet connection is not intact and needs to be inspected. Contact the University of Connecticut Biomedical Engineering Department for further details.

  - If the glove has become wet or glued in some fashion, corrosion is a high possibly and will have be taken care of by the University of Connecticut.

- In the event that the casing of the mechanics comes off, please contact the University of Connecticut and explain the situation. This is most likely due to the wearing of a rivet and can be easily replaced by the Biomedical Engineering Department.
- The mechanics may become misaligned with the hand. To realign the mechanics, carefully move them along the rings until they are running parallel with fingers.

- If the mechanics become loosened from the inner glove. Remove the outer glove by untying the release strings and unstitching the outer glove at the finger tips and the wrist band. Once the outer glove is off, check the mechanics to see if they have either been removed from the inner glove or are misaligned. Place the mechanics within the rings in an inline position and sew the tip with holes to the tip of the inner glove. Then, sew the opposite end of the mechanics to the other end of the hand. The glove should look similar to the image below. Once complete, place the outer glove over the inner glove and reattach the release mechanism strings.

![Figure 67. Rings of the inner glove](image_url)

- Breaking of any of the mechanics requires replacement of parts by the University of Connecticut. User shall not try to replace any of these parts on their own.
• Fixing the release mechanism of the Human Integrated Gripping Device

- When using the Human Integrated Gripping Device, make sure to follow the procedure set forth in the Introduction section 1.2 of this Operator’s Manual (Page 11). This will eliminate most problems that occur when attempting to put on the glove.

- If the release strings are not opening up, please see section: Releasing the Human Integrated Gripping Device in the Trouble Shooting portion of this Operator’s Manual.

- In the event that one of the release mechanism strings break, user can attempt to retie the string to the attachment site. If the string can not be recovered or retied contact the University of Connecticut.

- The tubular casing that runs through the inner glove can become loosened and affect the performance of the release mechanism. If this is the case, remove the outer glove by unstitching it at the tips of the fingers and at the wrist. Untie all the release mechanism strings and take off the outer glove. Realign the tubular plastic casing so that it fits within the stainless steel rings of each side of the glove. Super glue may be used to reconnect all the tubes together. Once connected, sew the tubes onto the inner glove. Replace the outer glove and restitch as well as tie on release mechanism strings. If procedure does not work, please contact the University of Connecticut.

Figure 68. Tubular casing of release mechanism shown in yellow
- If the tubular casing runs outside of the glove, the user can attempt to push it back into the glove. In the event that this fails, the user may coat tubular casing with some cloth or other substance as to protect it from outside environment. Please contact the University of Connecticut for further assistance.

- Wear and tear of the release holes may become evident after prolonged use. These can be repaired by either sewing or glueing the tear shut.

Figure 69. Release holes
- **Fixing the glove interface of the Human Integrated Gripping Device**

- When using the Human Integrated Gripping Device, make sure to follow the procedure set forth in the Introduction section 1.2 of this Operator’s Manual (Page 11). This will eliminate most problems that occur when attempting to put on the glove.

- After extensive use of the Human Integrated Gripping Device, the outer glove may become worn and need replacing. This can be done by the user. Purchase an EMS glove liner from your local retailer. Unstitch the old liner from the Human Integrated Gripping Device and untie the release mechanism strings. Replace the old liner with the newly purchased liner. Stitch on the new liner and replace the release mechanism strings.

![Figure 70. Outer glove](image)

- The Velcro may wear off or come off after extensive use of the Human Integrated Gripping Device. Purchase Velcro at your local hardware store or Velcro retailer. Remove old Velcro from the outer glove and reapply new Velcro. Velcro in some sections may have to be unstitched to remove and restitched to apply.
- Replacement of the hook may also be needed after long periods of use. This hook is specially made, please contact the University of Connecticut to obtain details on replacing the part.

- Damage to the inner glove requires extensive repair. If the user finds rips, tears, wearing, holes, or any other deformations, the user must contact the University of Connecticut. Do not attempt to fix the inner glove on one’s own.

**Figure 71.** Velcro on backhand of glove

**Figure 72.** Inner glove workings
• Replacing Parts

- All parts used to make the Human Integrated Gripping Device are specially ordered or made. They can not be reproduced nor replaced without explicit instruction through the University of Connecticut. If any part becomes worn or damaged, please contact the Biomedical Engineering Department for details.
Figure 74. Prototype Design 2
Figure 75. Finished prototype design of Human Integrated Gripping Device
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