IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reexamination of:
U.S. Patent No. 12,070,867

Control No. Not yet assigned Confirmation No. Not yet assigned

Inventor(s): Alexander J. Lonsberry et al.

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Art Unit: Not yet assigned

Examiner: Not yet assigned

Attorney's Docket No. 2120-0001

Title: Autonomous Welding Robots

MS EX PARTE REEXAM
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR *EX PARTE* REEXAMINATION
UNDER 37 CFR 1.510

Dear Commissioner:

Third-party Requester requests *ex parte* reexamination of U.S. Patent No. 12,070,867 (the present patent, or the `867 patent). The present patent was filed on September 18, 2023. The present patent claims priority from two U.S. non-provisional applications and the benefit of two U.S. provisional applications. As will become relevant below, the first U.S. provisional application (No. 63/153,109) was filed February 24, 2021, and the second (No. 63/282,827) was filed November 24, 2021. A copy of the present patent is submitted as Exhibit A.

I. Claims for Which Re-examination is Requested

Requester requests *ex parte* re-examination of all claims (1-20) of the present patent.

Requester submits that substantial new questions of patentability are raised by four printed publications, the details of which are provided below.

None of these publications were cited during the prior examination. Further, they are not merely cumulative to the prior art considered during prior examination. The publications provide disclosures the examiner suggested were missing from the prior art in allowing the claims.

Furthermore, Requester submits all of the claims are anticipated by at least one of the publications and are obvious in view of at least two different combinations of the publications. In fact, the claims may also be obvious in view of the publications and the previously cited art to the extent the publications provide disclosure missing from the previously cited prior art.

II. Prior Art Relied Upon

A complete list of the publications cited herein is as follows:

1. Zych, "Programming of Welding Robots in Shipbuilding", Procedia CIRP 99 (2021) 478-483 ("Zych")[1];

2. Larkin et al., "3D Mapping using a ToF Camera for Self Programming an Industrial Robot", (2013) 2013 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM) ("Larkin");

3. Rout et al., "Advances in weld seam tracking techniques for robotic welding: A review", Robotics and Computer Integrated Manufacturing 56 (2018) 12-37 ("Rout"); and

[1] Although this publication includes a footnote that it is a "resupply of March 2023", the content is the same as the version that was accessible online as of May 3, 2021, as detailed in the attached Declaration of Paul Craane.

4. Hong et al., "Online Extraction of Pose Information of 3D Zigzag-Line Welding Seams for Welding Seam Tracking", Sensors 2021, 21, 375, ("Hong").

Copies of these publications (the "cited publications") are submitted as Exhibits B-E, respectively.

III. <u>Substantial New Question of Patentability</u>

For *ex parte* re-examination of the present patent to be ordered, a substantial new question of patentability must be present with respect to at least one claim. To present a substantial new question of patentability, the prior art relied upon must be important to deciding whether a claim is patentable, but the prior art need not establish a prima facie case of unpatentability. However, in this case, the prior art is not merely important but also establishes a prima facie case of unpatentability.

In particular, the cited publications represent prior art disclosures and teachings that were not present during the examination of the present patent, and that are analogous art. Furthermore, the questions of patentability raised by the cited publications were not previously resolved during the original prosecution, and in this regard the cited publications are not cumulative of the previously cited and applied references. These previously unconsidered, non-cumulative, prior art disclosures and teachings either anticipate or render obvious all claims, as described in the claim charts below.

A. The Claimed Autonomous Robotic Welding Systems and Methods

The alleged invention claimed in the '867 patent relates to autonomous robotic welding systems and related methods configured to capture images of a workspace, identify a seam between objects to be welded and one or more "fixtures" that hold the objects to be welded in place, ***and generate a welding path that avoids collision with such fixtures.***

With regard to identifying a seam and a fixture from images of the workspace, the patentee stated that this may be done using one or more neural networks to perform pixel-wise and/or point-wise classification "to identify each imaged structure within the workspace **101** as a part **114**, as a seam on the part **114** or at an interface between multiple parts **114** (referred to herein as candidate seams), as a fixture **116**, as the robot **110**, etc."(Col. 9, lines 1-34).

With regard to fixtures, the patentee stated that these may be "clamps, platforms, positioners, or other types of fixtures" that "hold, position, and/or manipulate" parts to be welded (Col. 4, lines 3-12).

With regard to collision avoidance, the patentee stated that "a collision analysis as described herein may be performed by comparing a 3D model of the workspace **101** and a 3D model of the robot **110** to determine whether the two models overlap, and optionally, some or all of the triangles overlap. … The controller **108** may repeat this process as needed until a collision-free path has been planned." (Col. 17, lines 31-57).

Thus, according to the '867 Patent, generating a welding path "wherein the welding path is planned considering whether the welding tool or the robotic arm is predicted to collide with the one or more fixtures" as recited in claim 1, or a welding path "generated to provide a collision free path of the robot arm, the welding tool, both, with respect to the fixture" as recited in independent claims 8 and 16, is interpreted to encompass a trial-and-error approach as described at Col. 17, lines 31-57, wherein the controller determines a path that would follow a seam, and then checks each point along the path (referred to a "waypoint-node pair") to determine if a collision is likely, and if so try an alternate path.

However, the claims are not limited to such point-by-point collision detection techniques, but instead purport to encompass any sort of collision avoidance when generating a welding path.

B. The Claims are not entitled to a Priority Date of February 24, 2021

As indicated above, the claimed subject matter of the ‘867 patent requires collision avoidance, particularly relative to the fixtures.

Provisional patent application No. 63/153,109 filed February 24, 2021 (the “first provisional”) contains ***no*** mention of collisions, or of planning a path to avoid collisions. As such, the first provisional contains no mention of collision avoidance relative to fixtures. Accordingly, any claims directed to planning a robotic welding path to avoid collisions with fixtures (i.e., ***all*** claims of the ‘867 Patent) are ***not*** entitled to the benefit of the filing date of the first provisional.

Provisional application No. 63/282,827 filed November 24, 2021 (the “second provisional”), includes some discussion about path planning and collision avoidance. However, it is not clear whether the second provisional provides sufficient disclosure of the subject matter of the claims of the ‘867 patent in the manner provided by 35 USC 112(a) to support a priority claim under 35 USC 119(e), especially considering the breadth of the claims attempted by the patentee. Requester takes no position on whether the second provisional provides such support because the prior art status of the cited publications can be resolved based on the ‘867 patent’s lack of entitlement to the February 24, 2021 date.

C. The Cited Publications are thus uncited, analogous, prior art

Initially, even if the claims of the ‘867 Patent are entitled to the benefit of the November 24, 2021 filing date of the second provisional, this filing date is after the dates on which each of the cited publications were publicly accessible. Specifically, Zych was publicly accessible as of May 3, 2021, Larkin as of August 22, 2013, Rout as of September 4, 2018, and Hong as of January 7, 2021. See Declaration of Paul Craane. Each of these dates is earlier than the November 24, 2021 date that Requester submits is, at best, the earliest date to which the claims of the ‘867 patent are entitled (without taking a position on their actual entitlement to the November 24, 2021 date). Consequently, the cited publications are prior art to the claims of the ‘867 patent.

Additionally, none of the cited publications were cited during the examination of the ‘876 patent. This fact is evident from the face of the ‘867 patent, which lists none of the cited publications. In addition, review of the Forms PTO-1449 (modified) submitted to the Office and the Forms PTO-892 provided by the Office in the prosecution history of the ‘867 patent shows that none of the cited publications were disclosed to or by the Office. Thus, the cited publications are uncited prior art.

Finally, the cited publications are analogous art.

As is well known to those skilled in the art, planning of motions/paths to avoid collisions is a fundamental concept in robotics. For example, as acknowledged in paragraph [0002] in the “Background” section of the second provisional, “in known manufacturing robots, a skilled operator may facilitate path/ motion planning and provide instructions to the robot for avoiding collisions.”

One skilled in the art will appreciate that with respect to robotic path planning, there is no substantive difference between a collision with a “fixture” and a collision with any other obstacle to the motion of the robot (including collisions with a part of the robot itself). By way of analogy, just as it would be obvious to apply a technique for an autonomous vehicle to avoid hitting a dog to also avoid hitting a cat, it would likewise be obvious to apply a technique for a welding robot to avoid collisions with clamps to also avoid collisions with positioners, welding tables, or any other objects in the workspace.

The cited references are not merely disclosures in the general field of machine vision or robotic path planning, however. The cited references are specifically directed to the field of automated welding robots. As such, it would be obvious for a person skilled in the art to combine the teachings of the cited publications (even potentially with the references cited during the examination of the ‘876 patent) and arrive at the subject matter of the claims of the ‘867 patent. The skilled person would be motivated to combine these teachings to identify fixtures and other obstacles in a workspace and avoid collisions therewith and would have a reasonable expectation of success.

D. Allowance of the Claims emphasized identification of seams and fixtures using a robot controller

While the claimed invention requires collision avoidance of fixtures, the examiner did not allow the claims simply on this feature. Rather, the prosecution history suggests the absence of the identification of seams and fixtures using a robot controller in the cited prior art led to allowance.

Admittedly, the prosecution history of the ‘867 patent is quite limited. When the application resulting in the ‘867 patent was originally filed it contained 26 claims. The original claims were cancelled by a preliminary amendment and replaced with claims 27-46. Based on these claims, the first substantive official action was a Notice of Allowance.

The Notice of Allowance (the “NOA”) included Reasons for Allowance. In the Reasons for Allowance, the examiner identified one reference as “primary” (Miegel-US20080114492), and two references as “secondary” (Louban-US20130259376 and Chang-US20200114449) (collectively, the “cited prior art”). In doing so, the examiner concluded that “these references do not cover enough of the claim’s scope to warrant a rejection.”

In particular, the examiner stated:

> Miegel is silent in disclosing (i) a robot controller configured to: (ii) based on image data associated with one or more images of the workspace and received from one or more sensors: (iii) identify the fixture in the workspace; and (iv) identify the seam in the workspace; and (v) the welding path generated to provide a collision free path of the robot arm, the welding tool, both, with respect to the fixture.

Secondary reference, Louban (US 20130259376) discloses based on image data associated with one or more images of the workspace and received from one or more sensors: and identify the seam in the workspace (see figure 2), but not using a robot controller:

Louban is silent in disclosing identify the fixture in the workspace.

Secondary reference, Chang (US 20200114449) discloses the welding path generated to provide a collision free path of the robot arm, the welding tool, both, with respect to the fixture …" (NOA, pages 6-7, numbering added)

When the disclosure of Louban and Chang is compared with Miegel's "silence," the examiner identifies (ii) and (iv) disclosed in Louban and (v) in Chang. Thus, it appears that the basis for allowance of the '867 Patent was that fact that none of the references considered by the Examiner disclosed using a robot controller (item (i)) to identify seams and fixtures based on one or more images of the workspace (item (iii)).

E. The Cited Publications disclose identification of seams and fixtures using a robot controller

Requester submits that the cited publications, either alone or in combination, disclose or teach the subject matter that the examiner did not find in the cited prior art when allowing the claims. That is, it was well known in the art to use a robotic controller to identify seams, fixtures, and other objects in a robotic welding workspace based on images of the workspace, and plan a welding path based thereon, before the effective filing date of the claimed invention of the '867 Patent. As such, the cited publications are not cumulative of the cited prior art.

<u>The Zych Publication</u>

As described below, Requester submits that Zych both anticipates and renders obvious each and every claim of the '867 patent. Relative to the identification of seams and fixtures using a robot controller, Requester submits that Zych provides the disclosure and/or teaching allegedly missing from the cited prior art.

Specifically, Zych discloses methods for automating programming of controllers of welding robots, including CAD-based programming, hybrid programming, and, most relevantly, sensor-based programming. In relation to sensor-based programming, Zych explicitly teaches scanning a working area to generate a 3D representation thereof:

> In the first step, three-dimensional digitalization of the tack-welded components is carried out. For this purpose the 3D sensor system usually is being moved to different scanning positions within the working area to digitalize the complete components with minimal shadings. (Zych at p. 481)

Zych further discloses generating a point cloud for identifying individual parts of the working area, specifically with collision avoidance in mind:

> Fig. 5 shows the result of such point cloud segmentation procedure with identified individual parts of a box. … Furthermore, postprocessor's functionality had to be extended with regard to process and trajectory planning methods to cope with the high risk of collision in confined spaces and the infinite solution space due to redundancy of the kinematic structure. (Zych at p. 482)

Moreover, this 3D representation includes both seams and ***fixtures***. For example, Fig. 5 of Zych, reproduced below, is of a point cloud that includes fixtures in the form of brackets[2]:

[2] Reference numerals have been added to Fig. 5 to replace the colors used in the original to differentiate between the plates, stiffeners, and brackets.

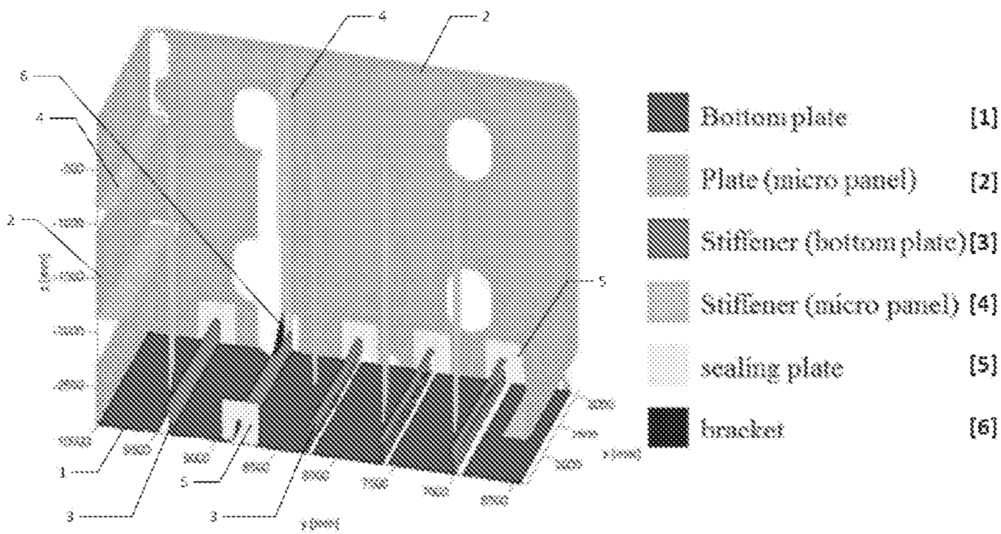

Fig. 5. Segmented point cloud of a box

One would recognize that the brackets of Fig. 5 are fixtures, as that term is used in the '867 patent, for the following reasons. The '867 patent states, for example, at col. 7, line 64 that "fixtures" may be "e.g., a . . . positioner" and at col. 6, lines 44-45, that "a positioner" may be "e.g., platform, clamps, etc." From this, it follows that a clamp (such as those used to "minimize gaps between plates and profiles" as disclosed in Zych) is a fixture, and also that other structures that similarly maintain a spatial relationship between pieces would be fixtures. As such, the brackets used to "increase stiffness between plates and profiles" (p. 479, first column, first paragraph) would be fixtures.

<u>The Larkin Publication</u>

While a paper by Larkin et al. (entitled "Automatic program generation for welding robots from CAD") was cited during the examination of the '867 patent, this Larkin et al. paper was directed to CAD-based programming of welding robots. In contrast, presently-cited Larkin, like Zych, is specifically directed to sensor-based programming of welding robots. Moreover, Larkin discusses the identification of seams and fixtures using a robot controller.

For example, the introduction of Larkin states that relative to CAD-based programming:

> The problem for AOLP systems is the reliance on accurate CAD geometry. AOLP relies on the assumption that the work environment is modeled accurately in its entirety. AOLP conducted by the authors for industry has demonstrated that incorrect CAD information is a key source of error for AOLP systems. These errors often go unnoticed until a robot collision occurs.

Larkin thus introduces a method of programming that extends the concept of AOLP to ***remove*** the reliance of CAD information. ***An additional sensor added to the robot is used to map the work environment to generate the information usually obtained from CAD data. This enables a form of self programming, where the robot is able to perform a task without conventional programming.*** Specifically, the focus of Larkin is 3D mapping using a ToF camera, with a motion planning algorithm where modifications to a generic algorithm are proposed and examined. (Larkin, p. 494, emphasis added)

<u>The Rout Publication</u>

As to the identification of seams and fixtures using a robot controller, Rout is a review paper that discusses various techniques for identifying and tracking seams in robotic welding. It is clear from the teachings of Rout that using ***a robot controller*** to identify seams based on one or more images of the workspace was well known as of the effective filing date of the claimed invention of the ‘867 Patent.

<u>The Hong Publication</u>

As to the identification of seams and fixtures using a robot controller, Hong discloses methods for extracting pose information for 3D zigzag-welding seams suitable for real-time tracking of welding seams. Hong also includes detailed examples of identifying workpieces and welding seams using point cloud data.

F. The Newly Applied Art Renders the Claims Anticipated or Unpatentable

Taken together, sections A-E show that the cited publications raise a substantial new question of patentability at least by virtue of the fact that they are newly cited, analogous prior art that discloses or teaches the features of the claims that, according to the NOA, were not disclosed in the cited prior art considered during the original prosecution, and thus would have been important to the Examiner in allowing claims 1-20.

In addition to the arguments raised above, a further substantial new question of patentability is raised by the fact that, the teachings of the cited references on their own render claims 1-20 anticipated or unpatentable, as explained in greater detail below. In particular, Requester submits that:

(1) Claims 1-20 are unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych.

(2) Claims 1-20 are unpatentable under 35 U.S.C. 103 as being obvious over Hong in view of Zych, and further in view of Larkin.

(3) Claims 1-20 are unpatentable under 35 U.S.C. 103 as being obvious over Rout in view of Zych, and further in view of Larkin.

IV. <u>Detailed Application of the References to the Claims</u>

In consideration of the fact that a substantial new question of patentability is raised by the cited publications, Requester provides the following detail explanation of how the claims of the present application are anticipated and/or unpatentable in view of the cited publications. This explanation is not intended as an exhaustive listing of every possible disclosure for each element that may be found in the cited prior art, but rather is illustrative of teachings in the prior art. Further, nothing in this explanation should be interpreted as an acquiescence as to a particular claim construction, that the claims of the present patent are amendable to a construction, or that the claims comply with the statutory requirements of 35 U.S.C. 112 or any other requirement for patentability.

A. Zych under 35 U.S.C. 102

Independent Claim 1

According to the construction given to claim 1, claim 1 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych.

‘867 Patent	Zych
Claim 1 recites an autonomous robotic welding system comprising:	At p. 479 Zych discloses robotic welding systems wherein “the positioning of profiles is […] automated” (first column, paragraph following bullet points). At p. 480, Zych discloses that “trajectory planning based on CAD data and automatic collision avoidance” (second column, fourth full paragraph) and “automatic creation of tags (seam identification) based on predefined rules” (second column, fifth full paragraph) were known in the art. At p. 481, Zych discloses robotic welding systems wherein “automatic processing of acquired 3D data is performed” and “[a]fter identification of component geometry and seams, an initial sequence of weld seams is determined based on predefined rules” (second column, third full paragraph).
a controller configured to:	At p. 481, Zych discloses that a “control system” is one of several “required components” for “sensor-based robot programming” (second column).
instruct one or more sensors to capture multiple images of a	Zych at p. 481 discloses use of “3D sensor hardware” for “three-dimensional digitalization of the tack-welded components”, wherein the “3D sensor system usually is being

workspace, the workspace including:	moved to different scanning positions within the working area to digitalize the complete components […]" (second column, second full paragraph). Zych also discloses this process may comprise taking "[a] preliminary, low-resolution acquisition to determine overall component structure and a detailed acquisition stage with optimized sensor positions according to the current component positions" (second column, second full paragraph). So there is no confusion, while p. 481 states "tack-welded components," Zych at p. 479 discloses that positioning may be by tack welding or "mechanized by positioning devices" (p. 479, first column, first bullet point).
one or more fixtures configured to temporarily secure first and second weldable objects on a positioner in a way that aligns the first and second weldable objects to form a seam; and	Zych at p. 479 discloses a workspace comprising a "clamping system" that autonomously positions profiles to "minimize the gaps between plates and profiles" (first column, paragraph following bullet points). In this regard, the '867 patent states at col. 6, lines 44-45, for example, "a positioner" may be "(e.g., platform, clamps, etc.)," and at col. 7, line 64 that "fixtures" may be "(e.g., a platform or positioner)" such that fixture and positioner appear to be used interchangeably. Zych at p. 482 teaches a workspace comprising stiffeners, sealing plates, and brackets (see Fig. 5).
a robotic arm coupled to a welding tool, the welding tool configured to perform a welding	Zych at p. 479 discloses "robotic welding of seams between individual components" using "six-axis articulated robots" (first column, second bullet point).

operation along the seam;	
identify at least the one or more fixtures and the seam based on one or more images of the multiple images;	Zych at p. 481 discloses a sensor-based robotic welding system using “acquired 3D data” based on one or more images to identify the “shape and location of individual parts” and to “determine seams to be welded” (second column, third full paragraph). Zych at p. 482 (first column, second paragraph) states, in relation to the extension of sensor-based programming to volume sections, “The major challenge to this approach was to deal with the significantly more complex component structures with regard to 3D data acquisition, data processing and trajectory planning since the robot will have to work in confined spaces with a high risk of collision. Therefore, adaptive scanning strategies have been developed as well as iterative segmentation procedures. Fig. 5 shows the result of such point cloud segmentation procedure with identified individual parts of a box.” Further, Fig. 5 clearly shows a representation of a workspace wherein one or more fixtures (e.g. the “bracket”) are identified.
generate a welding path for a robot to follow when welding the seam, wherein the welding path is planned considering	Zych at p. 481 (second column, third full paragraph) discloses that “[a]fter identification of component geometry and seams, an initial sequence of weld seams is determined […]” (i.e., generated welding path). Zych also discloses at p. 481 (second column, fourth full paragraph) that the data is processed and “converted into a robot program by means of a postprocessor”.

whether the welding tool or the robotic arm is predicted to collide with the one or more fixtures; and	Zych at p. 480 (second column, fourth full paragraph) discloses that "alternative OLP [Offline Programming] systems [have been] developed, including trajectory planning based on […] automatic collision avoidance." Zych at p. 482 (first column, second paragraph) adds that "sensor-based programming systems" use "adaptive scanning strategies" to address the "3D data acquisition, data processing and trajectory planning" because "the robot will have to work in confined spaces with a high risk of collision."
instruct the robot to weld the seam according to the generated welding path.	Zych at p. 481 in Fig. 3 discloses a "production line concept" wherein the robot program instructs a welding robot to complete an operation according to the generated welding path. See also, p. 481, second column, fourth full paragraph ("respective production data is converted into a robot program by means of a post processor").

Dependent Claim 2

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Zych
Claim 2 recites the autonomous robotic welding system of claim 1,	Zych at p. 479 (first column, first bullet point) discloses that the "[p]ositioning and tack welding of individual components" can be "mechanized by positioning

wherein the controller is configured to manipulate a pose of the positioner.	devices”. In the paragraph immediately following the bullet points in the first column of p. 479, Zych discloses automating the positioning of profiles with a clamping system. Such an “automated […] clamping system” is included “to minimize the gaps between plates and profiles”. Requester submits that this inherently discloses or teaches manipulation (in an automated fashion, by the controller) of a pose of the positioner.

Dependent Claim 3

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 1, see the discussion regarding claim 1 above.

‘867 Patent	Zych
Claim 3 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to constrain the positioner in one or more specific configurations when welding the seam.	Zych at p. 479 (first column, first bullet point) discloses that the “positioning and tack welding of individual components” can be “mechanized by positioning devices”. In the paragraph immediately following the bullet points in the first column of p. 479, Zych discloses automating the positioning of profiles with a clamping system. Such an “automated […] clamping system” is included “to minimize the gap between plates and profiles”. Requester submits that this inherently discloses or teaches (in an automated fashion, by the controller) the positioner being constrained in at least one or more specific configurations when welding the seam.

Dependent Claim 4

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 3, see the discussion regarding claim 3 above.

‘867 Patent	Zych
Claim 4 recites the autonomous robotic welding system of claim 3, wherein the controller is configured to manipulate the positioner to force the welding tool to be in a 1F welding position or a 2F welding position relative to the seam.	Zych at p. 479 (first column, first bullet point) discloses that “positioning […] of individual components” can be “mechanized by positioning devices”. Zych continues at p. 479 (second column, last paragraph) that “[d]eviations of component positions and geometry require the use of sensor information to adapt robot trajectories”. Requester submits that positioning individual components and adapting robot trajectories inherently discloses or teaches holding the welding tool at a 1F or 2F welding position (while 1F and 2F weld positions are not defined in the ‘867 patent, one skilled in the art would understand 1F and 2F to refer to flat or horizontal welding positions, which are two of the most commonly used welding positions). Likewise, in a system where both the welding tool and the positioner are automated, the positioner may be manipulated to force the welding tool to be in a welding position, such as the 1F or 2F position.

Dependent Claim 5

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 1, see the discussion regarding claim 1 above.

‘867 Patent	Zych

Claim 5 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to generate one or more motion parameters for the positioner, and wherein the motion parameters facilitate coordinated motion between the robotic arm and the positioner.	Zych at p. 479 discloses that the "positioning and tack welding of individual components" can be "mechanized by positioning devices" (first column, first bullet point), such as by an "automated […] clamping system" that "minimize[s] the gap between plates and profiles" (first column, paragraph after bullet points). As such, the controller in Zych generates one or more position parameters for the positioner. Further, Zych also discloses that the "welding process [may start] directly after clamping the profile." Thus, the motion parameters facilitate coordinated motion between the robotic arm and the positioner such that welding may start after clamping. Zych discloses shipbuilding welding systems wherein "workpieces are transferred between different work stations (e.g., by means of roller conveyor)" (p.479, second column, paragraph after bullet points; see also Fig. 2). Distinct stations may be used for "workpiece positioning" and "welding". Requester submits that both examples inherently require that the autonomous robotic welding systems comprise coordinated motion between the robotic arm and the positioner.

Dependent Claim 6

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Zych
Claim 6 recites the autonomous robotic	Zych at p. 481 discloses a 3D sensor system that may capture "a preliminary, low-resolution acquisition to

welding system of claim 1, wherein the controller is configured to identify the one or more fixtures and the seam based on a pixel-wise classification technique performed on the multiple images.	determine overall component structure and a detailed acquisition stage with optimized sensor positions according to the current component positions" (second column, second paragraph). The "acquired 3D data" is used to determine the "shape and location of individual parts" and the "seams to be welded (tag creation)" (second column, third paragraph). Requester submits that identification of the shape and location of individual parts from this image data, with tag creation, inherently discloses or teaches a pixel-wise classification technique to identify the fixtures and the seam.

Dependent Claim 7

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Zych
Claim 7 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to identify the one or more fixtures and the seam based on a point-wise classification technique performed on a point cloud generated using the multiple images.	Zych at p. 482 (first column, second paragraph) discloses that acquired 3D data based on one or more images can be used in a "point cloud segmentation procedure" to visualize individual parts of a box to be welded in a "segmented point cloud" (see Fig. 5).

Independent Claim 8

According to the construction given to claim 8, claim 8 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych.

‘867 Patent	Zych
Claim 8 recites a welding robotic system, comprising: a robot arm positioned in a workspace, the robot arm coupled to a welding tool configured to weld two objects together along a seam formed between multiple objects positioned in the workspace;	Zych at p. 479 (first column, second bullet point) discloses “robotic welding of seams between individual components [being performed] usually with six-axis articulated robots”, which the Requester implicitly discloses or teaches that a welding robotic system may comprise a robotic arm coupled to a welding tool configured to weld two objects (“individual components”) together along a seam formed between the objects in a workspace.
a fixture positioned in the workspace and including a positioner, the positioner configured to: secure a first object of multiple objects; and position the first object in a relationship with a second object of the multiple objects to form the seam; and	Zych at p. 479 (first column, first paragraph) discloses the use of “brackets”, “collar plates”, and “sealing plates” to “increase stiffness between plates and profiles”. Zych also discloses use of an “automated […] clamping system to minimize the gaps between plates and profiles” (p. 479, first column, paragraph after bullet points). In this regard, the ‘867 patent states, for example at col. 6, lines 44-45, that “a positioner” may be “(e.g., platform, clamps, etc.) and at col. 7, line 64 that “fixtures” may be “(e.g., a platform or positioner)” such that fixture and positioner appear to be used interchangeably”
a robot controller configured to: based on image data associated with one or more images of the	Zych at p. 481 (second column, fifth full paragraph) discloses that a “control system” is a “required component” for a “sensor-based robot

workspace and received from one or more sensors:	programming approach". Zych discloses that sensor-based robotic welding systems can comprise "3D sensor hardware" that generates 3D data based on one or more images (e.g., "[a] preliminary, low resolution acquisition" and "a detailed acquisition") (p. 481, second column, second full paragraph).
identify the fixture in the workspace; and identify the seam in the workspace;	Zych at p. 481 (second column, third full paragraph) discloses that the acquired 3D data may be used to identify the "shape and location of individual parts" and to "determin[e] seams to be welded (tag creation)."
generate, based on a position of the identified fixture in the workspace, a welding path for the robotic arm to follow to weld at least a portion of the identified seam, the welding path generated to provide a collision free path of the robot arm, the welding tool, both, with respect to the fixture; and instruct the robot arm move the welding tool to weld at least the portion of the seam according to the generated welding path.	Zych at p. 480 (second column, fourth full paragraph) discloses that "alternative OLP [Offline Programming] systems [have been] developed, including trajectory planning based on […] automatic collision avoidance." Zych at p. 481 (second column, third full paragraph) discloses sensor-based programming for welding systems which, "[a]fter identification of component geometry and seams" using acquired 3D data based on one or more images, generate "an initial sequence of weld seams […]" (i.e., a welding path). This data is processed and converted into a "robot program" by a "postprocessor" and used to instruct a welding robot to weld two objects together along the welding path while avoiding collisions with objects in the workspace (p. 481, second column, fourth full paragraph).

Dependent Claim 9

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 8, see the discussion regarding claim 8 above.

‘867 Patent	Zych
Claim 9 recites the welding robotic system of claim 8, wherein: the robot controller is configured to transform the image data associated with the one or more images into a point cloud; and the robot controller is configured to identify the fixture in the point cloud using point-wise classification.	Zych at p. 481-482 discloses that acquired 3D data based on one or more images can be used to generate a “segmented point cloud” (see p. 482, Fig. 5). Zych at p. 482 (first column, second paragraph) also discloses that such a “point cloud segmentation procedure” may be used to identify “individual parts” or fixtures in the workspace, such as a “bottom plate”, a “stiffener”, or a “bracket” (see Fig. 5).

Dependent Claim 10

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 8, see the discussion regarding claim 8 above.

‘867 Patent	Zych
Claim 10 recites the welding robotic system of claim 8, further comprising: the one or more sensors; and wherein the one or more sensors are coupled to the robot arm.	Zych at p. 479 (second column, third paragraph) discloses that welding robotic systems may comprise “touch sensing” via a “wire tip or gas nozzle”, or “optical sensors […] for seam finding.” Zych at p. 481 (second column, second paragraph) also discloses that such sensors can be positioned by a “welding robot gantry or a separate kinematic

	device". Requester submits that this inherently includes the robotic arm.

Dependent Claim 11

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Zych
Claim 11 recites the welding robotic system of claim 8, wherein, to identify the fixture, the robot controller is further configured to perform a finding operation.	Zych at p. 481 (second column, third full paragraph) discloses that the acquired 3D data may be used to identify the "shape and location of individual parts." Requester submits that identifying the "shape and location of individual parts" inherently involves performing a finding operation and includes the fixture.

Dependent Claim 12

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 11, see the discussion regarding claim 11 above.

'867 Patent	Zych
Claim 12 recites the welding robotic system of claim 11, wherein, to perform the finding operation, the robot controller is further configured to: perform a pixel-wise classification operation on the one or more images; or perform a point-wise classification operation	Zych at p. 482 (first column, second paragraph) discloses that acquired 3D data based on one or more images may be used to generate a "segmented point cloud" (see Fig. 5). Such a "point cloud segmentation procedure" may be used to find

on a point cloud, the point cloud generated based on the one or more images.	"individual parts" in a workspace, such as a "bottom plate", a "stiffener", or a "bracket" (p. 482, first column, second paragraph; see Fig. 5).

Dependent Claim 13

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Zych
Claim 13 recites the welding robotic system of claim 8, wherein the robot controller is configured to: determine a position of the identified seam in the workspace based on a computer aided design (CAD) model and the image data.	Zych at p. 480-81 discloses systems that use offline programming (OLP) "based on [computer aided design] CAD data and automatic collision avoidance" (p. 480, second column, fourth full paragraph), wherein "either CAD-data or user input [can be used] to determine seam parameters (tag creation)" (p. 481, first column, third full paragraph). Zych discloses examples of systems using "2D machine vision to identify workpiece locations and CAD data to obtain workpiece geometry", and systems using a "stereo vision system" in combination with "CAD data […] to provide necessary workpiece information" (p. 481, first column, fourth full paragraph).

Dependent Claim 14

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Zych
Claim 14 recites the welding robotic system of claim 8, wherein: the robot controller is further configured to receive the image data from one or more sensors as the one or more images; and each sensor of the one or more sensors is configured to generate respective sensor data associated with the workspace.	Zych at p. 481 (second column, fifth full paragraph) discloses "sensor-based robot[s]" comprising a "control system", and a 3D sensor system that may capture "a preliminary, low-resolution acquisition to determine overall component structure and a detailed acquisition stage with optimized sensor positions according to the current component positions" (second column, second full paragraph). These images are used to generate "acquired 3D data" and identify "component geometry and seams" within a workspace (p. 481, second column, third full paragraph).

Dependent Claim 15

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Zych
Claim 15 recites the welding robotic system of claim 8, wherein: the robot controller is further configured to: generate welding instructions based on the welding path; and transmit the welding instructions to the robot arm coupled to the welding tool; and	Zych at p. 481 (second column, fifth full paragraph) discloses a method of "sensor-based robot programming" that processes 3D data to identify the "shape and location of individual parts", the "seams to be welded (tag creation)", and to determine "an initial sequence of weld seams" (i.e., generated welding

the robot arm is configured to operate the welding tool to weld the first and second objects together along at least the portion of the seam based on the welding instructions.	instructions) (second column, third full paragraph). The data is processed and used to generate a "robot program" that is transmitted to and implemented by a welding robotic system to complete a welding operation according to the welding instructions (see p. 481, second column, fifth full paragraph, and Fig. 3).

Independent Claim 16

According to the construction given to the claim 16, claim 16 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych.

'867 Patent	Zych
Claim 16 recites a computer-implemented method of generating welding instructions for a welding robot, the computer-implemented method comprising: receiving, from one or more sensors, image data associated with one or more images of a workspace;	Zych at p. 481 (first column, first three full paragraphs) discloses a method of "sensor-based robot programming" using a "3D sensor system" to generate "acquired 3D data" based on one or more images (e.g., "low-resolution acquisition[s]" and "detailed acquisition[s]") which identifies the "shape and location of individual parts" and "seams to be welded" in the workspace.
based on the image data associated with one or more images of the workspace: identifying a fixture in the workspace, the fixture including	Zych at p. 479 (first column, first bullet point) discloses that robotic welding systems may comprise "mechanized […] positioning devices" for manipulating one or more objects to be welded. The positioning device may be an "automated […]

a positioner configured to: secure a first object of multiple objects; and position the first object in a relationship with a second object of the multiple objects to form a seam between the first object and the second object; and identifying the seam in the workspace;	clamping system" that can operate in coordination with the welding system (e.g., "The welding process starts directly after clamping […]" (p. 479, first column, first paragraph after bullet points)). Zych at p. 481-482 discloses that acquired 3D data is used to identify "individual parts" and "component geometry" of objects in the workspace (e.g., p. 481, second column, third full paragraph). Requester submits that such objects include the positioner and other fixtures (e.g., stiffeners, sealing plates, and brackets in Fig. 5). Zych at p. 481 (second column, third full paragraph) discloses that "acquired 3D data" may be used to determine "seams to be welded (tag creation)" and create "an initial sequence of weld seams."
generating, based on a position of the identified fixture in the workspace, a welding path for a robotic arm to follow to weld at least a portion of the identified seam, the robot arm positioned in a workspace and coupled to a welding tool configured to weld the first and second objects together along the seam, and	Zych at p. 479 (first column, second bullet point) discloses that robotic welding systems may comprise "six-axis articulated robots" for welding of seams. Zych at p. 481 (second column, third full paragraph) discloses a method of "sensor-based [robot] programming" that processes 3D data to identify the "shape and location of individual parts", the "seams to be welded (tag creation)", and to determine "an initial sequence of weld seams" (i.e., generated welding path).
wherein the welding path is generated to provide a collision free path of the robot arm, the	Zych at p. 480 (second column, fourth full paragraph) discloses that "alternative OLP [Offline Programming] systems [have been] developed,

welding tool, both, with respect to the fixture; and	including trajectory planning based on [...] automatic collision avoidance." Zych at p. 480-481 discloses that avoiding collisions is a consideration of CAD-based methods and hybrid methods. Requester submits that collision avoidance is also an inherent feature of sensor-based programming methods.
instructing the robot arm move the welding tool to weld at least the portion of the seam according to the generated welding path.	Zych discloses that the 3D data is processed and used to generate a "robot program" that is implemented by the welding robotic system to complete a welding operation according to the welding path (see Fig. 3).

Dependent Claim 17

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 16, see the discussion regarding claim 16 above.

'867 Patent	Zych
Claim 17 recites the computer-implemented method of claim 16, further comprising manipulating a pose of the positioner.	Zych at p. 479 (first column, first bullet point) discloses the "positioning and tack welding of individual components" being "mechanized by positioning devices". In the paragraph immediately following the bullet points in the first column of p. 479, Zych discloses automating the positioning of profiled with a clamping system. Such "automated [...] clamping systems" bring two objects together to "minimize the gaps between plates and profiles". Requester submits that this inherently discloses or teaches manipulation (in an automated fashion) of a pose

	of the positioner.

Dependent Claim 18

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 16, see the discussion regarding claim 16 above.

‘867 Patent	Zych
Claim 18 discloses the computer-implemented method of claim 16, wherein the positioner is constrained in one or more specific configurations during welding of the seam.	Zych at p. 479 (first column, first bullet point) discloses the “positioning and tack welding of individual components” being “mechanized by positioning devices”. In the paragraph immediately following the bullet points in the first column of p. 479, Zych discloses automating the positioning of profiles with a clamping system. Such “automated […] clamping systems” bring two objects together to “minimize the gaps between plates and profiles”. Requester submits that this inherently discloses or teaches (in an automated fashion, by the controller) the positioner being constrained in at least one or more specific configurations when welding the seam.

Dependent Claim 19

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 16, see the discussion regarding claim 16 above.

‘867 Patent	Zych
Claim 19 discloses the computer-implemented	Zych at p. 479 discloses that a robotic welding system may comprise “six-axis articulated robots” for welding,

method of claim 16, further comprising: generating one or more motion parameters for the positioner; and wherein the motion parameters facilitate coordinated motion between the robotic arm and the positioner.	and that the “positioning and tack welding of individual components” can be “mechanized by positioning devices” (first column, first bullet point), such as an “automated […] clamping system” (first column, paragraph after bullet points). As such, one or more position parameters are generated for the positioner in Zych. Further, Zych also discloses that the “welding process [may start] directly after clamping […].” Thus, the motion parameters facilitate coordinated motion between the robotic arm and the positioner such that welding may start after clamping. Zych discloses shipbuilding welding systems wherein “workpieces are transferred between different work stations (e.g., by means of roller conveyor)” (p. 479, second column, paragraph after bullet points; see also Fig. 2). Distinct stations may be used for “workpiece positioning” and “welding”. Requester submits that both examples inherently require that the autonomous robotic welding systems comprise coordinated motion between the robotic arm and the positioner.

Dependent Claim 20

This claim is unpatentable under 35 U.S.C. 102(a) as being anticipated by Zych. As to the limitations of claim 16, see the discussion regarding claim 16 above.

‘867 Patent	Zych
Claim 20 discloses the computer-implemented method of claim 16,	Zych at p. 481-482 discloses that 3D data based on one or more images may be used to

wherein the fixture and the seam are identified based on: a pixel-wise classification technique performed on the image data associated with the one or more images; or a point-wise classification technique performed on a point cloud generated using the image data associated with the one or more images.	determine "seams to be welded (tag creation)" (p. 481, second column, third paragraph), and to generate a "segmented point cloud" (see Fig. 5). Such a "point cloud segmentation procedure" may be used to identify "individual parts" or fixtures within the workspace such as a "bottom plate", a "stiffener", or a "bracket" (see Fig. 5).

B. Hong in view of Zych further in view of Larkin under 35 U.S.C. 103

<u>Independent Claim 1</u>

According to the construction given to claim 1, claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin.

'867 Patent	Hong/Zych/Larkin
Claim 1 recites an autonomous robotic welding system comprising:	At p. 2 (third paragraph) Hong discloses that "RGB-D sensor[s are] commonly used 3D measurement sensor[s]" for "welding, mobile robots, […]", and "an arc-welding robot" operating according to a "RGB-D sensor-based auto path generation method".
a controller configured to:	In Figure 10 at p. 10 Hong discloses an autonomous robotic welding system comprising a "robot controller".
instruct one or more sensors to capture multiple images of a workspace, the workspace	At p. 2 (third paragraph) Hong discloses an RGB-D sensor "obtain[ing] an image of a welding environment as well as information about the depth

including:	of welding seams.” At p. 3 (second full paragraph) Hong discloses use of a “laser displacement sensor” to “scan the workpiece” and obtain multiple “frame[s] of data measured at a particular time”. Requester submits that the latter inherently includes capturing multiple images of a workspace.
one or more fixtures configured to temporarily secure first and second weldable objects on a positioner in a way that aligns the first and second weldable objects to form a seam; and	At p. 8 (second paragraph) Hong discloses that the welding process must adapt to the “influence of complex welding conditions such as welding workpiece clamping, […]”. Such clamps are depicted in Figures 14 (a) and (b) on p. 16 of Hong
a robotic arm coupled to a welding tool, the welding tool configured to perform a welding operation along the seam;	In Figure 10 of p. 10 Hong discloses a robotic arm with “five degrees of freedom”, which can be adjusted at “the welding torch”, “the welding attitude”, and the “rotating shaft”, wherein these points are adjusted “to adapt to the swing welding process”.
identify at least the one or more fixtures and the seam based on one or more images of the multiple images;	At p. 3 (first full paragraph) Hong discloses “a method for the fast acquisition of the point cloud data for 3D zigzag-line welding seams”. Hong does not explicitly teach one or more fixtures being identified based on one or more images; however, Zych at p. 481 discloses a sensor-based robotic welding system using “acquired 3D data” based on one or more images to identify the “shape and location of individual parts” and for “determine[ing the] seams to be welded” and Fig. 5 of Zych clearly shows a representation of a

	workspace wherein one or more fixtures (e.g. the "bracket") are identified. Further, Larkin et al. at p. 496 discloses that trajectory planning may comprise generating a collision free path from one location to another without colliding with any "space occupied by obstacles" (which could include fixtures or any other obstacles in the work environment) (first column, first paragraph). It would be obvious to one skilled in the art to incorporate identification of fixtures as taught by Zych and Larkin into the techniques disclosed by Hong, as these are all analogous art and the skilled person would be motivated to scan the workspace to identify fixtures (and any other obstacles) to avoid collisions.
generate a welding path for a robot to follow when welding the seam, wherein the welding path is planned considering whether the welding tool or the robotic arm is predicted to collide with the one or more fixtures; and	At p. 2 (third paragraph) Hong discloses a "weld path [being] generated by the auto path generation algorithm and used to assist the teaching of [a] welding robot […]". At p. 8 (first paragraph) Hong discloses that "planning [of] the path of the welding robot is required to maintain the continuity of the displacement, speed and acceleration of the welding robot." Hong also discloses that "[i]n the actual welding process, due to the influence of complex welding conditions such as *welding workpiece clamping*, assembly and deformation, the attitude of the welding seam will change unpredictably" (p. 8,

	second paragraph) At p. 9, Hong discloses that "[f]or a 3D zigzag-line welding seam workpiece, the welding robot can adjust the torch attitude online according to the welding seam attitude to ensure the welding quality."
instruct the robot to weld the seam according to the generated welding path.	At p. 10 Hong discloses that "[t]he 3D pose information for the welding seams was transmitted to the controller of the welding robot so that the robot could complete the welding task", and at p. 11 Hong discusses a welding experiment conducted to verify the above methods, which included using an algorithm that measured "path fitting" as a timed variable (see Table 3 on p. 17).

Dependent Claim 2

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Hong/Zych/Larkin
Claim 2 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to manipulate a pose of the positioner.	Zych at p. 479 discloses that the "positioning and tack welding of individual components" can be "mechanized by positioning devices". Such an "automated […] clamping system" would "minimize the gap between plates and profiles". Requester submits that this inherently involves manipulation of a pose of the positioner.

Dependent Claim 3

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Hong/Zych/Larkin
Claim 3 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to constrain the positioner in one or more specific configurations when welding the seam.	Zych at p. 479 discloses that the "positioning and tack welding of individual components" can be "mechanized by positioning devices". Such an "automated […] clamping system" would "minimize the gap between plates and profiles". Requester submits that this inherently involves the positioner being constrained in at least one or more specific configurations when welding the seam.

Dependent Claim 4

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 3, see the discussion regarding claim 3 above.

'867 Patent	Hong/Zych/Larkin
Claim 4 recites the autonomous robotic welding system of claim 3, wherein the controller is configured to manipulate the positioner to force the welding tool to be in a 1F welding position or a 2F welding	Zych at p. 479 discloses that "positioning […] of individual components" can be "mechanized by positioning devices", and that "deviations of component positions and geometry require the use of sensor information to adapt robot trajectories". Requester submits that positioning individual components and adapting robot trajectories

position relative to the seam.	inherently includes holding the welding tool at a 1F or 2F welding position (which, as one skilled in the art understands, are simply flat or horizontal welding positions, which are two of the most commonly used welding positions).

Dependent Claim 5

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

‘867 Patent	Hong/Zych/Larkin
Claim 5 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to generate one or more motion parameters for the positioner, and wherein the motion parameters facilitate coordinated motion between the robotic arm and the positioner.	Zych at p. 479 discloses that the “positioning and tack welding of individual components” can be “mechanized by positioning devices”, such as by an “automated […] clamping system” that “minimize[s] the gap between plates and profiles.” Zych discloses that the “welding process [may start] directly after clamping the profile.” Zych also discloses shipbuilding welding systems wherein “workpieces are transferred between different work stations (e.g., by means of roller conveyor)”. Distinct stations may be used for “workpiece positioning” and “welding”. Requester submits that both examples inherently require that the autonomous robotic welding systems comprise coordinated motion between the robotic arm and the positioner.

Dependent Claim 6

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Hong/Zych/Larkin
Claim 6 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to identify the one or more fixtures and the seam based on a pixel-wise classification technique performed on the multiple images.	Zych at p. 481 discloses a 3D sensor system that may capture "a preliminary, low-resolution acquisition to determine overall component structure and a detailed acquisition stage with optimized sensor positions according to the current component positions." The "acquired 3D data" is used to determine the "shape and location of individual parts" and the "seams to be welded (tag creation)." Requester submits that identification of the shape and location of individual parts from this image data inherently involves a pixel-wise classification technique to identify the fixtures and the seam. Further, Larkin at p. 495 discloses mapping the work environment to indicate object free space and the locations of objects, wherein "[t]he output of the ToF camera is a two-dimensional matrix, *I,* representing the distance to the detected object for each pixel."

<u>Dependent Claim 7</u>

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Hong/Zych/Larkin

Claim 7 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to identify the one or more fixtures and the seam based on a point-wise classification technique performed on a point cloud generated using the multiple images.	Hong at p. 6-7 discloses extraction of point cloud data of 3D zigzag-line welding seams. Zych at p. 482 discloses that acquired 3D data based on one or more images can be used in a "point cloud segmentation procedure" to visualize individual parts of a box to be welded in a "segmented point cloud" (see Fig. 5).

Independent Claim 8

According to the construction given to claim 8, claim 8 is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin.

'867 Patent	Hong/Zych/Larkin
Claim 8 recites a welding robotic system, comprising: a robot arm positioned in a workspace, the robot arm coupled to a welding tool configured to weld two objects together along a seam formed between multiple objects positioned in the workspace;	In Figure 10 of p. 10 Hong discloses a robotic arm with "five degrees of freedom", which can be adjusted at "the welding torch" and used to weld two objects together along a seam formed between multiple objects positioned in the workspace (see "workpiece" in Figure 10).
a fixture positioned in the workspace and including a	In Figure 14 of p. 16 Hong discloses a "positioner" (the "clamp" in Fig. 14(a) and (b)) in the workspace

positioner, the positioner configured to: secure a first object of multiple objects; and position the first object in a relationship with a second object of the multiple objects to form the seam; and	that secures a first object (vertical pane) and positions the first object in a relationship with a second object (horizontal pane) to form a seam.
a robot controller configured to: based on image data associated with one or more images of the workspace and received from one or more sensors:	At p. 10 Hong discloses a welding robot system comprising a “laser displacement sensor”, and “3D reconstruction computer […]” and a “point cloud data processing computer” (i.e., the “controller”, see Fig. 10). At p. 3 (second full paragraph) Hong discloses use of the “laser displacement sensor” to “scan the workpiece” and obtain multiple “frame[s] of data measured at a particular time”. Requester submits that the latter implies that multiple images are captured of a workspace.
identify the fixture in the workspace; and identify the seam in the workspace;	At p. 10 Hong discloses that the laser displacement sensor obtains “data for the welding seams through the real-time detection of the welding workpiece”. Hong does not explicitly teach one or more fixtures being identified based on one or more images; however, Zych at p. 481 discloses a sensor-based robotic welding system using “acquired 3D data” based on one or more images to identify the “shape and location of individual parts” and for “determine[ing the] seams to be welded” and Fig. 5 of Zych clearly shows a representation of a workspace wherein one

	or more fixtures (e.g. the “bracket”) are identified. Further, Larkin et al. at p. 496 discloses that trajectory planning may comprise generating a collision free path from one location to another without colliding with any “space occupied by obstacles” (which could include fixtures or any other obstacles in the work environment) (first column, first paragraph). It would be obvious to one skilled in the art to incorporate identification of fixtures as taught by Zych and Larkin into the techniques disclosed by Hong, as these are all analogous art and the skilled person would be motivated to scan the workspace to identify fixtures (and any other obstacles) to avoid collisions.
generate, based on a position of the identified fixture in the workspace, a welding path for the robotic arm to follow to weld at least a portion of the identified seam, the welding path generated to provide a collision free path of the robot arm, the welding tool, both, with respect to the fixture; and	At p. 8 (first paragraph) Hong discloses that “planning [of a welding] path of the welding robot is required to maintain the continuity of the displacement, speed and acceleration of the welding robot.” Hong also discloses that “[i]n the actual welding process, due to the influence of complex welding conditions such as *welding workpiece clamping*, assembly and deformation, the attitude of the welding seam will change unpredictably” (p. 8, second paragraph). At p. 9, Hong discloses that “[f]or a 3D zigzag-line welding seam workpiece, the welding robot can adjust the torch attitude online according to the welding seam attitude to ensure the welding quality.” Requester submits that the above inherently requires a welding path for a robotic arm to be generated which welds at least a portion of the identified seam while avoiding

	collision with the robot arm/welding tool and the fixture.
instruct the robot arm move the welding tool to weld at least the portion of the seam according to the generated welding path.	At p. 10 Hong discloses that "[t]he 3D pose information for the welding seams was transmitted to the controller of the welding robot so that the robot could complete the welding task", and at p. 11 Hong discusses a welding experiment conducted to verify the above methods, which included using an algorithm that measured "path fitting" as a timed variable (see Table 3 on p. 17).

Dependent Claim 9

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Hong/Zych/Larkin
Claim 9 recites the welding robotic system of claim 8, wherein: the robot controller is configured to transform the image data associated with the one or more images into a point cloud; and the robot controller is configured to identify the fixture in the point cloud using point-wise classification.	Zych at p. 481-482 discloses that acquired 3D data based on one or more images can be used to generate a "segmented point cloud" (see Fig. 5). Zych at p. 482 also discloses that such a "point cloud segmentation procedure" may be used to identify "individual parts" or fixtures in the workspace, such as a "bottom plate", a "stiffener", or a "bracket" (see Fig. 5).

Dependent Claim 10

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

‘867 Patent	Hong/Zych/Larkin
Claim 10 recites the welding robotic system of claim 8, further comprising: the one or more sensors; and wherein the one or more sensors are coupled to the robot arm.	Zych at p. 479 discloses that welding robotic systems may comprise “touch sensing” via a “wire tip or gas nozzle”, or “optical sensors […] for seam finding.” Zych at p. 481 also discloses that such sensors can be positioned by a “welding robot gantry or a separate kinematic device”. Requester submits that the latter inherently includes a robotic arm.

Dependent Claim 11

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

‘867 Patent	Hong/Zych/Larkin
Claim 11 recites the welding robotic system of claim 8, wherein, to identify the fixture, the robot controller is further configured to perform a finding operation.	Zych at p. 481 discloses that the acquired 3D data may be used to identify the “shape and location of individual parts” and to “determin[e the] seams to be welded (tag creation).” Requester submits that identifying the shape and location of individual parts inherently involves performing a finding operation.

Dependent Claim 12

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 11, see the discussion regarding claim 11 above.

‘867 Patent	Hong/Zych/Larkin
Claim 12 recites the welding robotic system of claim 11, wherein, to perform the finding operation, the robot controller is further configured to: perform a pixel-wise classification operation on the one or more images; or perform a point-wise classification operation on a point cloud, the point cloud generated based on the one or more images.	Zych at p. 482 discloses that acquired 3D data based on one or more images may be used to generate a “segmented point cloud” (see Fig. 5). Such a “point cloud segmentation procedure” may be used to find “individual parts” in a workspace, such as a “bottom plate”, a “stiffener”, or a “bracket” (see Fig. 5).

Dependent Claim 13

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

‘867 Patent	Hong/Zych/Larkin
Claim 13 recites the welding robotic system of claim 8, wherein the robot controller is configured to: determine a position of the identified	Zych at p. 481 discloses systems that use offline programming (OLP) “based on [computer aided design (CAD)] data and automatic collision avoidance”, wherein “either CAD-data or user input [can be used] to determine seam parameters (tag

seam in the workspace based on a computer aided design (CAD) model and the image data.	creation)”. Zych provides examples of systems using “2D machine vision to identify workpiece locations and CAD data to obtain workpiece geometry”, and systems using a “stereo vision system” in combination with “CAD data […] to provide necessary workpiece information”.

Dependent Claim 14

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

‘867 Patent	Hong/Zych/Larkin
Claim 14 recites the welding robotic system of claim 8, wherein: the robot controller is further configured to receive the image data from one or more sensors as the one or more images; and each sensor of the one or more sensors is configured to generate respective sensor data associated with the workspace.	Zych at p. 481 discloses “sensor-based robot[s]” comprising a “control system”, and a 3D sensor system that may capture “a preliminary, low-resolution acquisition to determine overall component structure and a detailed acquisition stage with optimized sensor positions according to the current component positions”. These images are used to generate “acquired 3D data” and identify “component geometry and seams” within a workspace.

Dependent Claim 15

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

‘867 Patent	Hong/Zych/Larkin
Claim 15 recites the welding robotic system of claim 8, wherein: the robot controller is further configured to: generate welding instructions based on the welding path; and transmit the welding instructions to the robot arm coupled to the welding tool; and the robot arm is configured to operate the welding tool to weld the first and second objects together along at least the portion of the seam based on the welding instructions.	Zych at p. 481 discloses a method of “sensor-based robot programming” that processes 3D data to identify the “shape and location of individual parts”, the “seams to be welded (tag creation)”, and to determine “an initial sequence of weld seams” (i.e., generated welding instructions). The data is processed and used to generate a “robot program” that is transmitted to and implemented by a welding robotic system to complete a welding operation according to the welding instructions (see Fig. 3).

Independent Claim 16

According to the construction given to claim 16, claim 16 is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin.

‘867 Patent	Hong/Zych/Larkin
Claim 16 recites a computer-implemented method of generating welding instructions for a welding robot, the computer-implemented method comprising: receiving, from one or more sensors, image data associated	At p. 3 (first full paragraph) Hong discloses “a method for the online extraction of the pose information based on laser displacement sensing and density-based clustering point cloud segmentation.” Hong further discloses “a method for the fast acquisition of […] point cloud data for 3D zigzag-line welding seams”. At p. 10 Hong discloses a welding robot system

with one or more images of a workspace;	comprising a “laser displacement sensor”. At p. 3 (second full paragraph) Hong discloses use of the “laser displacement sensor” to “scan the workpiece” and obtain multiple “frame[s] of data measured at a particular time”. Requester submits that the latter inherently requires that multiple images are captured of a workspace.
based on the image data associated with one or more images of the workspace: identifying a fixture in the workspace, the fixture including a positioner configured to: secure a first object of multiple objects; and position the first object in a relationship with a second object of the multiple objects to form a seam between the first object and the second object; and	In Figure 14 of p. 16 Hong discloses a “fixture” (the “clamp” in Fig. 14(a) and (b)) in the workspace that secures a first object (vertical pane) and positions the first object in a relationship with a second object (horizontal pane) to form a seam. Hong does not explicitly teach one or more fixtures being identified based on one or more images; however, Zych at p. 481 discloses a sensor-based robotic welding system using “acquired 3D data” based on one or more images to identify the “shape and location of individual parts” and for “determine[ing the] seams to be welded” and Fig. 5 of Zych clearly shows a representation of a workspace wherein one or more fixtures (e.g. the “bracket”) are identified. Further, Larkin et al. at p. 496 discloses that trajectory planning may comprise generating a collision free path from one location to another without colliding with any “space occupied by obstacles” (which could include fixtures or any other obstacles in the work environment) (first column, first paragraph).

	It would be obvious to one skilled in the art to incorporate identification of fixtures as taught by Zych and Larkin into the techniques disclosed by Hong, as these are all analogous art and the skilled person would be motivated to scan the workspace to identify fixtures (and any other obstacles) to avoid collisions.
identifying the seam in the workspace;	At p. 10 Hong discloses that the laser displacement sensor obtains “data for the welding seams through the real-time detection of the welding workpiece”.
generating, based on a position of the identified fixture in the workspace, a welding path for a robotic arm to follow to weld at least a portion of the identified seam,	At p. 2 (third paragraph) Hong discloses a “weld path [being] generated by the auto path generation algorithm and used to assist the teaching of [a] welding robot […]”. At p. 8 (first paragraph) Hong discloses that “planning [of] the path of the welding robot is required to maintain the continuity of the displacement, speed and acceleration of the welding robot.” Hong also discloses that “[i]n the actual welding process, due to the influence of complex welding conditions such as *welding workpiece clamping*, assembly and deformation, the attitude of the welding seam will change unpredictably” (p. 8, second paragraph). At p. 9, Hong discloses that “for a 3D zigzag-line welding seam workpiece, the welding robot can adjust the torch attitude online according to the welding seam attitude to ensure the welding quality.”
the robot arm positioned in a	In Figure 10 on p. 10 Hong discloses a robotic arm

workspace and coupled to a welding tool configured to weld the first and second objects together along the seam, and	positioned in a workspace and coupled to a welding tool configured to weld a first and second object together along a seam (see “torch”, “workpiece”, “surface plate”, “polygonal line board”).
wherein the welding path is generated to provide a collision free path of the robot arm, the welding tool, both, with respect to the fixture; and	At p. 8 (first paragraph) Hong discloses that “planning [of a welding] path of the welding robot is required to maintain the continuity of the displacement, speed and acceleration of the welding robot.” Hong also discloses that “[i]n the actual welding process, due to the influence of complex welding conditions such as *welding workpiece clamping*, assembly and deformation, the attitude of the welding seam will change unpredictably” (p. 8, second paragraph). At p. 9, Hong discloses that “[f]or a 3D zigzag-line welding seam workpiece, the welding robot can adjust the torch attitude online according to the welding seam attitude to ensure the welding quality.” Requester submits that the above inherently requires a welding path for a robotic arm to be generated which welds at least a portion of the identified seam while avoiding collision with the robot arm/welding tool and the fixture.
instructing the robot arm move the welding tool to weld at least the portion of the seam according to the generated welding path.	At p. 10 Hong discloses that “[t]he 3D pose information for the welding seams was transmitted to the controller of the welding robot so that the robot could complete the welding task”, and at p. 11 Hong discusses a welding experiment conducted to verify the above methods, which included using an

	algorithm that measured "path fitting" as a timed variable (see Table 3 on p. 17).

Dependent Claim 17

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 16, see the discussion regarding claim 16 above.

'867 Patent	Hong/Zych/Larkin
Claim 17 recites the computer-implemented method of claim 16, further comprising manipulating a pose of the positioner.	Zych at p. 479 discloses the "positioning and tack welding of individual components" being "mechanized by positioning devices". Such positioning devices may be "automated […] clamping systems" that bring two objects together to "minimize the gaps between plates and profiles". Requester submits that this inherently involves manipulation of a pose of the positioner.

Dependent Claim 18

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 16, see the discussion regarding claim 16 above.

'867 Patent	Hong/Zych/Larkin
Claim 18 discloses the computer-implemented method of claim 16, wherein the positioner is constrained in one or more specific	Zych at p. 479 discloses the "positioning and tack welding of individual components" being "mechanized by positioning devices". Such positioning devices may be "automated […] clamping systems" that bring two objects together to "minimize the gaps between plates

configurations during welding of the seam.	and profiles". Requester submits that this inherently involves the positioner being constrained in at least one or more specific configurations when welding the seam.

Dependent Claim 19

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 16, see the discussion regarding claim 16 above.

'867 Patent	Hong/Zych/Larkin
Claim 19 discloses the computer-implemented method of claim 16, further comprising: generating one or more motion parameters for the positioner; and wherein the motion parameters facilitate coordinated motion between the robotic arm and the positioner.	Zych at p. 479 discloses that a robotic welding system may comprise "six-axis articulated robots" for welding, and "positioning and tack welding of individual components" using "mechanized by positioning devices", such as an "automated […] clamping system". Zych discloses that the "welding process [may start] directly after clamping […]." Zych also discloses shipbuilding welding systems wherein "workpieces are transferred between different work stations (e.g., by means of roller conveyor)". Distinct stations may be used for "workpiece positioning" and "welding". Requester submits that both examples inherently require that the autonomous robotic welding systems comprise coordinated motion between the robotic arm and the positioner.

Dependent Claim 20

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Hong in view Zych, and further in view of Larkin. As to the limitations of claim 16, see the discussion regarding claim 16 above.

'867 Patent	Hong/Zych/Larkin
Claim 20 discloses the computer-implemented method of claim 16, wherein the fixture and the seam are identified based on: a pixel-wise classification technique performed on the image data associated with the one or more images; or a point-wise classification technique performed on a point cloud generated using the image data associated with the one or more images.	Zych at p. 481-482 discloses that 3D data based on one or more images may be used to determine "seams to be welded (tag creation)", and to generate a "segmented point cloud" (see Fig. 5). Such a "point cloud segmentation procedure" may be used to identify "individual parts" or fixtures within the workspace such as a "bottom plate", a "stiffener", or a "bracket" (see Fig. 5).

C. Rout in view of Zych further in view of Larkin under 35 U.S.C. 103

<u>Independent Claim 1</u>

According to the construction given to claim 1, claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin.

'867 Patent	Rout/Zych/Larkin
Claim 1 recites an autonomous robotic welding system comprising:	In Figure 9 at p. 17 Rout discloses an autonomous robotic welding system. At p. 12 (first column) Rout discloses that "automation [...] implies the introduction of robot in the manufacturing

	processes for both physical production processes and processing information", and that such automated robots can be used for "welding" or "arc welding".
a controller configured to:	In Figure 9 at p. 17 Rout discloses an autonomous robotic welding system with a "robot controller". At p. 15 (second full paragraph) Rout also discloses "a high speed rotating arc sensor based on microprocessor based seam tracking controller system", and discloses a variety of controllers ("Human Simulated Intelligent Control (HSCI) controller", "PID controller", "neural network controller", and "Fuzzy controller").
instruct one or more sensors to capture multiple images of a workspace, the workspace including:	At p. 16 Rout discloses that "[c]omputer vision can be utilized to recognize and find the position of welding creases" (first column, second full paragraph), and that "a camera [can be] mounted […] above welding torch tip to capture *images* […]" (first column, third full paragraph).
one or more fixtures configured to temporarily secure first and second weldable objects on a positioner in a way that aligns the first and second weldable objects to form a seam; and	Rout does not explicitly teach one or more fixtures configured to temporarily secure first and second weldable objects on a positioner. However, the use of clamping mechanisms and positioners for holding weldable objects to form a seam is well known. For example, Zych at p. 479 discloses that the "positioning and tack welding of individual components" can be "mechanized by positioning devices". Such an "automated […] clamping system" would "minimize the gap between plates

	and profiles”.
a robotic arm coupled to a welding tool, the welding tool configured to perform a welding operation along the seam;	In Figure 9 at p. 17 Rout discloses a robotic arm coupled to a welding tool (“torch”) configured to perform a welding operation along a seam (“workpiece”). At p. 33 Rout also discloses a “welding torch” being “guide[d] […] along the weld seam line” by a “robotic arm” (second column, first paragraph).
identify at least the one or more fixtures and the seam based on one or more images of the multiple images;	Rout does not explicitly teach identification of one or more fixtures based on one or more images of the multiple images. However, Zych at p. 481 discloses a sensor-based robotic welding system using “acquired 3D data” based on one or more images to identify the “shape and location of individual parts” and for “determine[ing the] seams to be welded” and Fig. 5 of Zych clearly shows a representation of a workspace wherein one or more fixtures (e.g. the “bracket”) are identified. Further, Larkin et al. at p. 496 discloses that trajectory planning may comprise generating a collision free path from one location to another without colliding with any “space occupied by obstacles” (which could include fixtures or any other obstacles in the work environment). It would be obvious to one skilled in the art to incorporate identification of fixtures as taught by Zych and Larkin into the techniques disclosed by Rout, as these are all analogous art and the skilled

	person would be motivated to scan the workspace to identify fixtures (and any other obstacles) to avoid collisions. At p. 16 (first column, second full paragraph) Rout discloses that "computer vision can be utilized to recognize and find the position of welding creases which can be used to arrange a way to weld the parts naturally." At p. 19 (second column) Rout also discloses "a seam tracking algorithm for detection of weld seam features from a single image."
generate a welding path for a robot to follow when welding the seam, wherein the welding path is planned considering whether the welding tool or the robotic arm is predicted to collide with the one or more fixtures; and	At p. 29 (first column, first full paragraph) Rout discloses "a seam welding path conversion algorithm [that] translate[s] the seam path to actual welding path considering the actual start position and travel of torch in Y and Z axis with the look ahead distance (LAD)." Rout does not explicitly teach the welding path being generated in consideration of the welding tool or robotic arm avoiding collision with one or more fixtures. However, Zych at p. 480 discloses that "alternative [Offline Programming] systems [have been] developed, including trajectory planning based on […] automatic collision avoidance." Zych at p. 480-481 discloses that avoiding collisions is a consideration of CAD-based methods and hybrid methods. Requester submits that collision

	avoidance is also an inherent feature of sensor-based programming methods. Further, Larkin et al. at p. 496 discloses that trajectory planning may comprise generating a collision free path from one location to another without colliding with any "space occupied by obstacles" (which could include fixtures or any other obstacles in the work environment). It would be obvious to one skilled in the art to incorporate collision avoidance as taught by Zych and Larkin into the techniques disclosed by Rout.
instruct the robot to weld the seam according to the generated welding path.	At p. 29 (first column, first full paragraph) Rout discloses that "features of weld seam extracted by the image processing technique [can be] used by the controller module of seam tracking system to guide [a] robot along the weld seam path."

<u>Dependent Claim 2</u>

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Rout/Zych/Larkin
Claim 2 recites the autonomous robotic welding system of claim 1, wherein the controller is	Zych at p. 479 discloses that the "positioning and tack welding of individual components" can be "mechanized by positioning devices". Such an "automated […] clamping system" would "minimize the gap between

configured to manipulate a pose of the positioner.	plates and profiles”. Requester submits that this inherently involves manipulation of a pose of the positioner.

Dependent Claim 3

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

‘867 Patent	Rout/Zych/Larkin
Claim 3 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to constrain the positioner in one or more specific configurations when welding the seam.	Zych at p. 479 discloses that the “positioning and tack welding of individual components” can be “mechanized by positioning devices”. Such an “automated […] clamping system” would “minimize the gap between plates and profiles”. Requester submits that this inherently involves the positioner being constrained in at least one or more specific configurations when welding the seam.

Dependent Claim 4

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 3, see the discussion regarding claim 3 above.

‘867 Patent	Rout/Zych/Larkin
Claim 4 recites the autonomous robotic welding system of claim 3, wherein the controller is	Zych at p. 479 discloses that “positioning […] of individual components” can be “mechanized by positioning devices”, and that “deviations of

configured to manipulate the positioner to force the welding tool to be in a 1F welding position or a 2F welding position relative to the seam.	component positions and geometry require the use of sensor information to adapt robot trajectories". Requester submits that positioning individual components and adapting robot trajectories inherently includes holding the welding tool at a 1F or 2F welding position (which, as one skilled in the art understands, are simply flat or horizontal welding positions, which are two of the most commonly used welding positions).

Dependent Claim 5

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Rout/Zych/Larkin
Claim 5 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to generate one or more motion parameters for the positioner, and wherein the motion parameters facilitate coordinated motion between the robotic arm	Zych at p. 479 discloses that the "positioning and tack welding of individual components" can be "mechanized by positioning devices", such as by an "automated […] clamping system" that "minimize[s] the gap between plates and profiles." Zych discloses that the "welding process [may start] directly after clamping the profile." Zych also discloses shipbuilding welding systems wherein "workpieces are transferred between different work stations (e.g., by means of roller conveyor)". Distinct stations may be used for "workpiece positioning" and "welding". Requester submits that both examples inherently require that the autonomous robotic welding systems comprise

and the positioner.	coordinated motion between the robotic arm and the positioner.

Dependent Claim 6

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

'867 Patent	Rout/Zych/Larkin
Claim 6 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to identify the one or more fixtures and the seam based on a pixel-wise classification technique performed on the multiple images.	Zych at p. 481 discloses a 3D sensor system that may capture "a preliminary, low-resolution acquisition to determine overall component structure and a detailed acquisition stage with optimized sensor positions according to the current component positions." The "acquired 3D data" is used to determine the "shape and location of individual parts" and the "seams to be welded (tag creation)." Requester submits that identification of the shape and location of individual parts from this image data inherently involves a pixel-wise classification technique to identify the fixtures and the seam. Further, Larkin at p. 495 discloses mapping the work environment to indicate object free space and the locations of objects, wherein "[t]he output of the ToF camera is a two-dimensional matrix, *I,* representing the distance to the detected object for each pixel."

Dependent Claim 7

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 1, see the discussion regarding claim 1 above.

‘867 Patent	Rout/Zych/Larkin
Claim 7 recites the autonomous robotic welding system of claim 1, wherein the controller is configured to identify the one or more fixtures and the seam based on a point-wise classification technique performed on a point cloud generated using the multiple images.	Zych at p. 482 discloses that acquired 3D data based on one or more images can be used in a “point cloud segmentation procedure” to visualize individual parts of a box to be welded in a “segmented point cloud” (see Fig. 5).

Independent Claim 8

According to the construction given to claim 8, claim 8 is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin.

‘867 Patent	Rout/Zych/Larkin
Claim 8 recites a welding robotic system, comprising: a robot arm positioned in a workspace, the robot arm coupled to a welding tool configured to weld two objects together along a seam formed between multiple	In Figure 9 at p. 17 Rout discloses a welding robotic system comprising a robot arm positioned in a workspace, coupled to a welding tool (“torch”), and configured to weld two objects together along a seam (“workpiece”). At p. 33 Rout also discloses a “welding torch” being “guide[d] [...] along the weld seam line” between two objects by a “robotic arm” (second column, first paragraph).

objects positioned in the workspace;	
a fixture positioned in the workspace and including a positioner, the positioner configured to: secure a first object of multiple objects; and position the first object in a relationship with a second object of the multiple objects to form the seam; and	Rout does not explicitly teach a fixture positioned in the workspace (e.g., a positioner), configured to secure a first and second object relative to each other to form a seam. However, the use of clamping mechanisms and positioners for holding weldable objects to form a seam is well known. For example, Zych at p. 479 discloses that the "positioning and tack welding of individual components" can be "mechanized by positioning devices". Such an "automated […] clamping system" would "minimize the gap between plates and profiles".
a robot controller configured to:	In Figure 9 at p. 17 Rout discloses a welding robotic system comprising a "robot controller". At p. 15 (second full paragraph) Rout also discloses "a high speed rotating arc sensor based on microprocessor based seam tracking controller system", and discloses a variety of controllers ("Human Simulated Intelligent Control (HSCI) controller", "PID controller", "neural network controller", and "Fuzzy controller").
based on image data associated with one or more images of the workspace and received from one or more sensors: identify the fixture in the	Rout does not explicitly teach identification of a fixture in a workspace based on image data associated with one or more images of said workspace. However, Zych at p. 481 discloses a sensor-based robotic welding system using "acquired 3D data" based on one or more images

workspace; and	to identify the "shape and location of individual parts" and for "determine[ing the] seams to be welded" and Fig. 5 of Zych clearly shows a representation of a workspace wherein one or more fixtures (e.g. the "bracket") are identified. Further, Larkin et al. at p. 496 discloses that trajectory planning may comprise generating a collision free path from one location to another without colliding with any "space occupied by obstacles" (which could include fixtures or any other obstacles in the work environment). It would be obvious to one skilled in the art to incorporate identification of fixtures as taught by Zych and Larkin into the techniques disclosed by Rout, as these are all analogous art and the skilled person would be motivated to scan the workspace to identify fixtures (and any other obstacles) to avoid collisions.
identify the seam in the workspace;	At p. 16 (first column, second full paragraph) Rout discloses that "[c]omputer vision can be utilized to recognize and find the position of welding creases which can be used to arrange a way to weld the parts naturally." At p. 19 (second column) Rout also discloses "a seam tracking algorithm for detection of weld seam features from a single image."
generate, based on a position of the identified fixture in the workspace, a welding path for	Rout does not explicitly teach generating, based on a position of an identified fixture, a welding path for the robotic arm to follow to weld at least a portion of

the robotic arm to follow to weld at least a portion of the identified seam, the welding path generated to provide a collision free path of the robot arm, the welding tool, both, with respect to the fixture; and	the identified seam, wherein the welding path is generated to provide a collision free path of the robot arm/welding tool with respect to the fixture. However, Zych at p. 480 discloses that “alternative [Offline Programming] systems [have been] developed, including trajectory planning based on […] automatic collision avoidance.” Zych at p. 480-481 discloses that avoiding collisions is a consideration of CAD-based methods and hybrid methods. Requester submits that collision avoidance is also an inherent feature of sensor-based programming methods. Further, Larkin et al. at p. 496 discloses that trajectory planning may comprise generating a collision free path from one location to another without colliding with any “space occupied by obstacles” (which could include fixtures or any other obstacles in the work environment). It would be obvious to one skilled in the art to incorporate collision avoidance as taught by Zych and Larkin into the techniques disclosed by Rout.
instruct the robot arm move the welding tool to weld at least the portion of the seam according to the generated welding path.	At p. 29 (first column, first paragraph) Rout discloses that “features of weld seam extracted by the image processing technique [can be] used by the controller module of seam tracking system to guide [a] robot along the weld seam path.”

Dependent Claim 9

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Rout/Zych/Larkin
Claim 9 recites the welding robotic system of claim 8, wherein: the robot controller is configured to transform the image data associated with the one or more images into a point cloud; and the robot controller is configured to identify the fixture in the point cloud using point-wise classification.	Zych at p. 481-482 discloses that acquired 3D data based on one or more images can be used to generate a "segmented point cloud" (see Fig. 5). Zych at p. 482 also discloses that such a "point cloud segmentation procedure" may be used to identify "individual parts" or fixtures in the workspace, such as a "bottom plate", a "stiffener", or a "bracket" (see Fig. 5).

<u>Dependent Claim 10</u>

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Rout/Zych/Larkin
Claim 10 recites the welding robotic system of claim 8, further comprising: the one or more sensors; and wherein the one or more sensors are coupled to the robot arm.	Zych at p. 479 discloses that welding robotic systems may comprise "touch sensing" via a "wire tip or gas nozzle", or "optical sensors […] for seam finding." Zych at p. 481 also discloses that such sensors can be positioned by a "welding robot gantry or a separate kinematic device". Requester submits that the latter inherently includes a robotic arm.

Dependent Claim 11

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Rout/Zych/Larkin
Claim 11 recites the welding robotic system of claim 8, wherein, to identify the fixture, the robot controller is further configured to perform a finding operation.	Zych at p. 481 discloses that the acquired 3D data may be used to identify the "shape and location of individual parts" and to "determin[e the] seams to be welded (tag creation)." Requester submits that identifying the shape and location of individual parts inherently involves performing a finding operation.

Dependent Claim 12

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 11, see the discussion regarding claim 11 above.

'867 Patent	Rout/Zych/Larkin
Claim 12 recites the welding robotic system of claim 11, wherein, to perform the finding operation, the robot controller is further configured to: perform a pixel-wise classification operation on the one or more images; or perform a point-wise classification	Zych at p. 482 discloses that acquired 3D data based on one or more images may be used to generate a "segmented point cloud" (see Fig. 5). Such a "point cloud segmentation procedure" may be used to find "individual parts" in a workspace, such as a "bottom plate", a "stiffener", or a

operation on a point cloud, the point cloud generated based on the one or more images.	"bracket" (see Fig. 5).

Dependent Claim 13

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Rout/Zych/Larkin
Claim 13 recites the welding robotic system of claim 8, wherein the robot controller is configured to: determine a position of the identified seam in the workspace based on a computer aided design (CAD) model and the image data.	Zych at p. 481 discloses systems that use offline programming (OLP) "based on [computer aided design (CAD)] data and automatic collision avoidance", wherein "either CAD-data or user input [can be used] to determine seam parameters (tag creation)". Zych provides examples of systems using "2D machine vision to identify workpiece locations and CAD data to obtain workpiece geometry", and systems using a "stereo vision system" in combination with "CAD data […] to provide necessary workpiece information".

Dependent Claim 14

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Rout/Zych/Larkin

Claim 14 recites the welding robotic system of claim 8, wherein: the robot controller is further configured to receive the image data from one or more sensors as the one or more images; and each sensor of the one or more sensors is configured to generate respective sensor data associated with the workspace.	Zych at p. 481 discloses "sensor-based robot[s]" comprising a "control system", and a 3D sensor system that may capture "a preliminary, low-resolution acquisition to determine overall component structure and a detailed acquisition stage with optimized sensor positions according to the current component positions". These images are used to generate "acquired 3D data" and identify "component geometry and seams" within a workspace.

Dependent Claim 15

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 8, see the discussion regarding claim 8 above.

'867 Patent	Rout/Zych/Larkin
Claim 15 recites the welding robotic system of claim 8, wherein: the robot controller is further configured to: generate welding instructions based on the welding path; and transmit the welding instructions to the robot arm coupled to the welding tool; and the robot arm is configured to operate the	Zych at p. 481 discloses a method of "sensor-based robot programming" that processes 3D data to identify the "shape and location of individual parts", the "seams to be welded (tag creation)", and to determine "an initial sequence of weld seams" (i.e., generated welding instructions). The data is processed and used to generate a "robot program" that is

welding tool to weld the first and second objects together along at least the portion of the seam based on the welding instructions.	transmitted to and implemented by a welding robotic system to complete a welding operation according to the welding instructions (see Fig. 3).

Independent Claim 16

According to the construction given to claim 16, claim 16 is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin.

‘867 Patent	Rout/Zych/Larkin
Claim 16 recites a computer-implemented method of generating welding instructions for a welding robot, the computer-implemented method comprising:	In Figures 8 and 9 at p. 17 Rout discloses a computer-implemented method of generating welding instructions for a welding robot.
receiving, from one or more sensors, image data associated with one or more images of a workspace;	In Figure 8 at p. 17 Rout discloses a computer-implemented method of seam tracking using a vision sensor that comprises “image acquisition” and “image processing”. Rout further discloses “capturing of weld seam image[s] by the vision sensor and selection of image[s]” to help “orient the torch accurately at its initial position” (p. 17, first column).
based on the image data associated with one or more images of the workspace: identifying a fixture in the	Rout does not explicitly teach identification of a fixture in a workspace based on image data associated with one or more images of a workspace. However, Zych at p. 481 discloses a sensor-based

workspace, the fixture including a positioner configured to: secure a first object of multiple objects; and position the first object in a relationship with a second object of the multiple objects to form a seam between the first object and the second object; and	robotic welding system using “acquired 3D data” based on one or more images to identify the “shape and location of individual parts” and for “determine[ing the] seams to be welded” and Fig. 5 of Zych clearly shows a representation of a workspace wherein one or more fixtures (e.g. the “bracket”) are identified. Further, Larkin et al. at p. 496 discloses that trajectory planning may comprise generating a collision free path from one location to another without colliding with any “space occupied by obstacles” (which could include fixtures or any other obstacles in the work environment). It would be obvious to one skilled in the art to incorporate identification of fixtures as taught by Zych and Larkin into the techniques disclosed by Rout, as these are all analogous art and the skilled person would be motivated to scan the workspace to identify fixtures (and any other obstacles) to avoid collisions.
identifying the seam in the workspace;	At p. 16 (first column, second full paragraph) Rout discloses that “[c]omputer vision can be utilized to recognize and find the position of welding creases which can be used to arrange a way to weld the parts naturally.” At p. 19 (second column) Rout also discloses “a seam tracking algorithm for detection of weld seam features from a single image.”
generating, based on a	In Figure 9 at p. 17 Rout discloses an autonomous

position of the identified fixture in the workspace, a welding path for a robotic arm to follow to weld at least a portion of the identified seam,	robotic welding system comprising a robotic arm coupled to a welding tool ("torch") that welds at least a portion of an identified seam ("seam tracking system in real time with vision sensor").
the robot arm positioned in a workspace and coupled to a welding tool configured to weld the first and second objects together along the seam, and wherein the welding path is generated to provide a collision free path of the robot arm, the welding tool, both, with respect to the fixture; and	Rout does not explicitly teach generating, based on a position of an identified fixture, a welding path for the robotic arm to follow to weld at least a portion of the identified seam, wherein the welding path is generated to provide a collision free path of the robot arm/welding tool with respect to the fixture. However, Zych at p. 480 discloses that "alternative [Offline Programming] systems [have been] developed, including trajectory planning based on […] automatic collision avoidance." Zych at p. 480-481 discloses that avoiding collisions is a consideration of CAD-based methods and hybrid methods. Requester submits that collision avoidance is also an inherent feature of sensor-based programming methods. Further, Larkin et al. at p. 496 discloses that trajectory planning may comprise generating a collision free path from one location to another without colliding with any "space occupied by obstacles" (which could include fixtures or any other obstacles in the work environment). It would be obvious to one skilled in the art to incorporate collision avoidance as taught by Zych and Larkin into the techniques disclosed by Rout.

instructing the robot arm move the welding tool to weld at least the portion of the seam according to the generated welding path.	At p. 29 (first column, first paragraph) Rout discloses that "features of weld seam extracted by the image processing technique [can be] used by the controller module of seam tracking system to guide [a] robot along the weld seam path."

Dependent Claim 17

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 16, see the discussion regarding claim 16 above.

'867 Patent	Rout/Zych/Larkin
Claim 17 recites the computer-implemented method of claim 16, further comprising manipulating a pose of the positioner.	Zych at p. 479 discloses the "positioning and tack welding of individual components" being "mechanized by positioning devices". Such positioning devices may be "automated […] clamping systems" that bring two objects together to "minimize the gaps between plates and profiles". Requester submits that this inherently involves manipulation of a pose of the positioner.

Dependent Claim 18

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 16, see the discussion regarding claim 16 above.

'867 Patent	Rout/Zych/Larkin
Claim 18 discloses the computer-implemented	Zych at p. 479 discloses the "positioning and tack welding of individual components" being "mechanized

method of claim 16, wherein the positioner is constrained in one or more specific configurations during welding of the seam.	by positioning devices". Such positioning devices may be "automated […] clamping systems" that bring two objects together to "minimize the gaps between plates and profiles". Requester submits that this inherently involves the positioner being constrained in at least one or more specific configurations when welding the seam.

Dependent Claim 19

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 16, see the discussion regarding claim 16 above.

'867 Patent	Rout/Zych/Larkin
Claim 19 discloses the computer-implemented method of claim 16, further comprising: generating one or more motion parameters for the positioner; and wherein the motion parameters facilitate coordinated motion between the robotic arm and the positioner.	Zych at p. 479 discloses that a robotic welding system may comprise "six-axis articulated robots" for welding, and "positioning and tack welding of individual components" using "mechanized by positioning devices", such as an "automated […] clamping system". Zych discloses that the "welding process [may start] directly after clamping […]." Zych also discloses shipbuilding welding systems wherein "workpieces are transferred between different work stations (e.g., by means of roller conveyor)". Distinct stations may be used for "workpiece positioning" and "welding". Requester submits that both examples inherently require that the autonomous robotic welding systems comprise coordinated motion between the robotic arm and the positioner.

Dependent Claim 20

This claim is unpatentable under 35 U.S.C. 103 as being obvious over Rout in view Zych, and further in view of Larkin. As to the limitations of claim 16, see the discussion regarding claim 16 above.

'867 Patent	Rout/Zych/Larkin
Claim 20 discloses the computer-implemented method of claim 16, wherein the fixture and the seam are identified based on: a pixel-wise classification technique performed on the image data associated with the one or more images; or a point-wise classification technique performed on a point cloud generated using the image data associated with the one or more images.	Zych at p. 481-482 discloses that 3D data based on one or more images may be used to determine "seams to be welded (tag creation)", and to generate a "segmented point cloud" (see Fig. 5). Such a "point cloud segmentation procedure" may be used to identify "individual parts" or fixtures within the workspace such as a "bottom plate", a "stiffener", or a "bracket" (see Fig. 5).

V. **Conclusion**

For the reasons given above, *ex parte* reexamination of claims 1-20 of the present patent is requested.

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