connecting tubes to be connected by the joint member; determining a stress direction and magnitude to be exerted by the plurality of connecting tubes at the joint member; and 3-D printing the joint member having a configuration that (1) accommodates the relative tube angle, tube size, and tube shape at each joint member, and (2) supports the stress direction and magnitude exerted by the plurality of connecting tubes.

[0006] In some embodiments, the space frame is configured to at least partially encloses a three-dimensional volume. Each connecting tube of the plurality of connecting tubes may have a longitudinal axis along a different plane. The space frame may be a vehicle chassis frame.

[0007] The method may further comprise 3-D printing centering features on at least a portion of the joint member. The centering features may be printed on a joint protrusion of the joint member configured to be inserted into a connecting tube. The characteristics of the centering features can be determined based on the stress direction and magnitude to be exerted by the plurality of connecting tubes at the joint member. The stress direction and magnitude to be exerted by the plurality of connecting tubes at the joint member may be determined empirically or computationally.

[0008] An additional embodiment of the disclosure may be directed to a vehicle chassis comprising: a plurality of connecting tubes; and a plurality of joint members, each joint member sized and shaped to mate with at least a subset of the plurality of the connecting tubes in the plurality of connecting tubes to form a three-dimensional frame structure, wherein the plurality of joint members are formed by a 3-D printer.

[0009] In some embodiments, each joint member of the plurality of joint members is sized and shaped such that the joint member contacts an inner surface and an outer surface of a connecting tube when the connecting tube is mated to the joint member. Optionally, at least one joint member of the plurality of joint members comprises internal routing features formed during 3-D printing of the joint member. The internal routing features may provide a network of passageways for transport of fluid through the vehicle chassis when the three-dimensional frame structure is formed. The internal routing features may provide a network of passageways for transport of electricity through electrical components throughout the vehicle chassis when the three-dimensional frame structure is formed.

[0010] The plurality of joint members may comprise mounting features formed during 3-D printing of the joint members. The mounting features may provide panel mounts for mounting of panels on the three-dimensional frame structure.

[0011] In a second aspect, there is provided a system for forming a structure comprising: a computer system that receives input data that describes a relative tube angle, tube size, and tube shape for each of a plurality of connecting tubes to be connected by a plurality of joint members to form a frame of the structure, wherein the computer system is programmed to determine a stress direction and magnitude to be exerted by the plurality of connecting tubes at the plurality of joint members: and a 3-D printer in communication with the computer system configured to generate the plurality of joint members having a size and shape that (1) accommodates the relative tube angle, tube size, and tube shape at each joint member, and (2) supports the stress direction and magnitude exerted by the plurality of connecting tubes.

[0012] In some cases, the frame of the structure at least partially encloses a three-dimensional volume. The plurality of joint members may further comprise centering features on at least a portion of the joint member formed by the 3-D printer. The centering features may be printed on a joint protrusion of the joint member configured to be inserted into a connecting tube. The characteristics of the centering features may be determined based on the stress direction and magnitude to be exerted by the plurality of connecting tubes at each joint member.

[0013] Additional aspects and advantages of the present disclosure will become readily apparent to those skilled in this art from the following detailed description, wherein only illustrative embodiments of the present disclosure are shown and described. As will be realized, the present disclosure is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the disclosure. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

INCORPORATION BY REFERENCE

[0014] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be

CLAIMS

WHAT IS CLAIMED IS:

1. A method of fabricating a joint member for connection of a plurality of connecting tubes forming a space frame, the method comprising:

determining a relative tube angle, tube size, and tube shape for each of the plurality of connecting tubes to be connected by the joint member;

determining a stress direction and magnitude to be exerted by the plurality of connecting tubes at the joint member; and

3-D printing the joint member having a configuration that (1) accommodates the relative tube angle, tube size, and tube shape at each joint member, and (2) supports the stress direction and magnitude exerted by the plurality of connecting tubes.

2. The method of claim 1, wherein the space frame is configured to at least partially enclose a three-dimensional volume.

3. The method of claim 1, wherein each connecting tube of the plurality of connecting tubes has a longitudinal axis along a different plane.

4. The method of claim 1, wherein the space frame is a vehicle chassis frame.

5. The method of claim 1, further comprising 3-D printing centering features on at least a portion of the joint member.

6. The method of claim 5, wherein the centering features are printed on a joint protrusion of the joint member configured to be inserted into a connecting tube.

7. The method of claim 5, wherein the characteristics of the centering features are determined based on the stress direction and magnitude to be exerted by the plurality of connecting tubes at the joint member.

8. The method of claim 1, wherein the stress direction and magnitude to be exerted by the plurality of connecting tubes at the joint member is determined empirically or computationally.

9. A system for forming a structure comprising:

a computer system that receives input data that describes a relative tube angle, tube size, and tube shape for each of a plurality of connecting tubes to be connected by a plurality of joint members to form a frame of the structure, wherein the computer system is programmed to determine a stress direction and magnitude to be exerted by the plurality of connecting tubes at the plurality of joint members: and

a 3-D printer in communication with the computer system configured to generate the plurality of joint members having a size and shape that (1) accommodates the relative tube