Smart Electromechanical Systems Modules

A.E. Gorodetskiy

Abstract The article considers design features of standard modules of smart electromechanical systems (SM SEMS). Also, shows that a variety of structures SM SEMS allow a variety of system design with broad technological capabilities. Further analyzed the applicability of various types of SM SEMS in different areas, taking into account their strengths and weaknesses. In conclusion, noted the expediency of building and exploring mathematical models, above all, the module SM8 SEMS, since it has the most complete functionality, and other modules are in some of the simplification.

Keywords Smart electromechanical systems · Standard module · Structure · Mathematical models

1 Introduction

The main elements of the SEMS is standard modules (standard modules—SM), having a structure such as hexapods. They allow you to maximize the accuracy of the actuators with the minimum travel time by introducing parallelism in measuring, calculating, moving and using precision motors. But however, such mechanisms have a more complex kinematics, which requires more advanced control algorithms and solving new, complex optimization problems, ensuring the implementation of the optimum path without jamming.

A.E. Gorodetskiy (✉)
Institute of Problems of Mechanical Engineering, Russian Academy of Sciences, Saint-Petersburg, Russia
e-mail: g27764@yandex.ru

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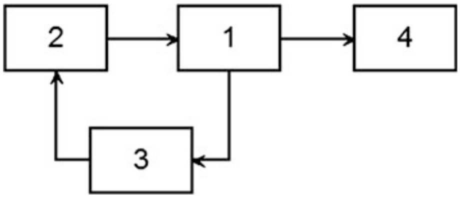


Fig. 1 The block diagram of SM SEMS

When building SEMS for various purposes can be used a wide variety of different standard modules. All they usually contain (see Fig. 1) electromechanical system (EMS) (1), a parallel type, an automatic control system (ACS) (2), the measuring system (MS) (3) and docking system (DS) (4).

EMS comprises a movable and a stationary platform and usually six legs. The difference of certain SM SEMS from each other mainly lies in the design platforms. The core of ACS is neuroprocessor automatic control system (NACS). The main function of NACS is the automatic control of the movement of the upper platform, which has, as a rule, 6-axis positioning system with a control unit. Also part of the function of NACS is the automatic configuration management upper and lower platforms by extending the control rod. MS generally contains, opto-electronic sensors elongation and displacement, tactile sensors and force sensors. DS, as a rule, contains a vision system with intelligent recognition unit.

Next, consider the design of the main modules SM SEMS.

2 Tripod—Module SM1 SEMS

Tripods comprise (see Fig. 2) the lower 1 and an upper platform 2 interconnected three legs 3–5 with the motors 6–8 through 9–14 two-stage hinges providing a change in their length, thus, it is possible to conduct positioning 3-linear m (X, Y, Z) and three angular coordinates (rotation around respective axes Qx, Qy, Qz) [1]. Tripods normally used as a platform to support the weight and maintain the stability of the fortified her another object, such as a camera or camcorder. They provide resistance against downward forces and horizontal forces and movements about horizontal axes. Positioning of three feet from the vertical center of gravity makes it easier to provide arms to resist lateral forces.

The main advantages of tripod are: small size, great rigidity, high positioning accuracy, freely configurable in terms of support, high repeatability of structural elements, the possibility of excluding backlash and no need for fine adjustment during assembly.

The disadvantages are the tripod: the complexity of manufacturing the linear actuator legs, complexity of the joints and complex control algorithms.

Fig. 2 The circuit design tripod and an example of its execution

3 Hexapod—Module SM2 SEMS

Hexapod or Hugh Stewart platform is a type of parallel manipulator, which uses the octahedral arrangement of pillars [1]. Hexapod has six degrees of freedom (three translational and three rotational, as an absolutely solid). The unit has (see Fig. 3) lower platform (LP) (1), the upper platform (AP) (2) and six legs—actuators (LA) (3–8). The lower and upper platform (5 and 6) each comprise a supporting platform (SP) (9 and 10), at least three rods (attached at one end to SP, and the other —to the mounting pads (MP) (17–19 and 20–22), to which may be attached, for example screwed, at least three telescopic spring-loaded rods (TSLR) (23–25 and 26–28).

LA contain electric drives (ED) with gearboxes (G), displacement sensors (DS), such as opto-electronic, and force sensors (FS), such as piezoelectric, and lower hinges (LH), attached to the mounting pads lower platform and top hinges (TH), attached to the mounting pads of the upper platform. By varying the length of the legs with the help of controlled drives, you can change the orientation of a single platform while fixing another.

Hexapod mechanisms used in those areas where it is necessary to control with great precision the object on three axes such as high-precision automatic machines, in medicine for complex operations. Just hexapod machines with high payloads are used in aircraft simulators and radio telescopes.

The main advantages compared with hexapod tripod are: good dynamic characteristics, and lack of accumulation of positional errors.

Hexapod disadvantages are the complexity of manufacturing the linear actuator leg joints complexity, complex control algorithms and possible seizure in violation of the synchronization of linear actuators.

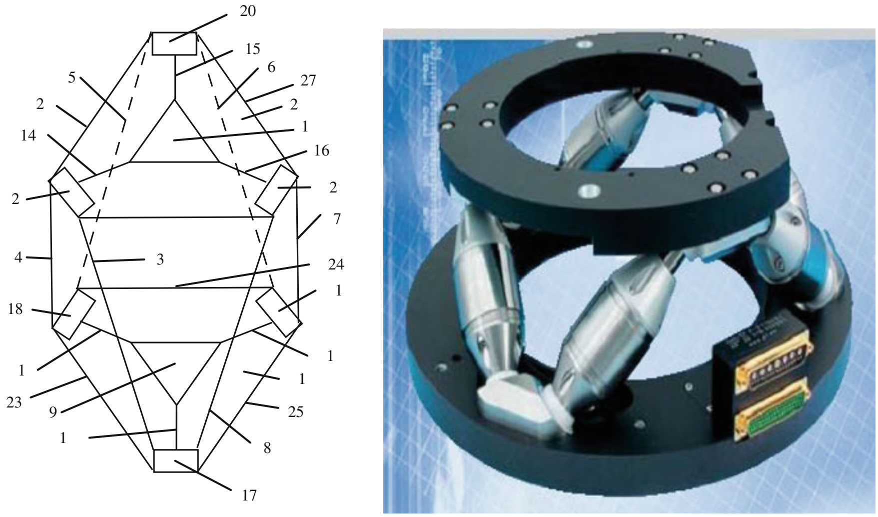


Fig. 3 Driving hexapod design and its general appearance

4 The Module SM3 SEMS

Unlike hexapod the module (see Fig 4) has rods 29–31 and 32–34, which are mounted on the MP 17–19 and/or 20–22 platforms 1 and/or 2 to rotate in planes passing through the points of attachment rods and center of the platform 1 and/or 2 perpendicular to the latter by means of a controlled drive 35–37 and 38–40. The rods 29–31 and 32–34 can change their length by means of linear control actuators 41–43 and 44–46. These rods make the module SM3 SEMS moved by their simultaneous turning and changing lengths. The latter can be used in the design of robots able to move, such as pipes or vessels [2]. Sometimes rods 29–31 and 32–34 can be elastic, which can be useful in medical robots.

SM3 SEMS module has the same advantages and disadvantages as the hexapod, but additionally has the ability to move in space.

5 The Module SM4 SEMS

Unlike module SM2 SEMS that module (see Fig. 5) has rods 47–49 and 50–52, inwardly directed platforms and which are mounted on the SP 9 and/or 10 the platforms 1 and/or 2. They can be rotated in planes reference platforms 9 and/or 10, using of controlled drives 53–55 and 56–58. The rods 47–49 and 50–52 can change their length by means of linear control actuators 59–61 and 62–64. The latter can be used in constructions gripper robots to capture different objects rods 47–49 and 50–52. Just as in the previous case, rods 47–49 and 50–52 can be flexible, which

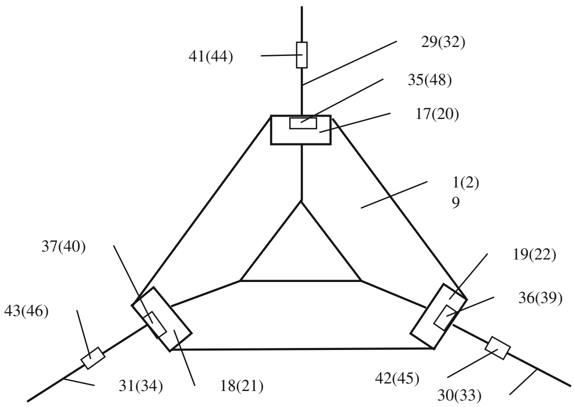


Fig. 4 Design platform of module SM3 SEMS

may be useful in medical robots, such as the Elizarova devices used for bone fixation at fractures [3].

6 The Module SM5 SEMS

The module SM5 SEMS unlike hexapod in rods 11–13 and/or 14–16) have (see Fig. 6) actuators 65–67 and/or 68–70, which allow you to change their length, i.e., making them the control rods (CR).

Usually CR actuators contain gearboxes (G), displacement sensors (DS), for example, optoelectronic, force sensors (FS), such as piezoelectric and controllers (C).

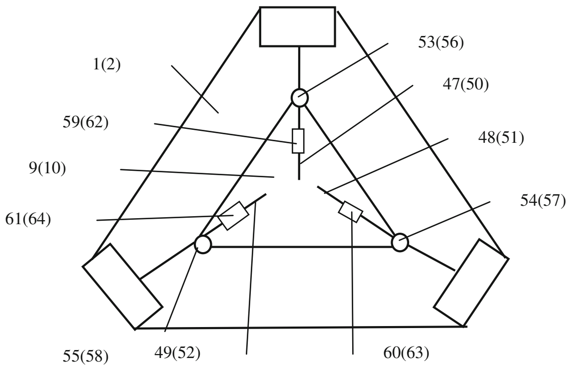
MP 17–19 and 20–22 comprise two grooves for securing TSLR 23–25 and 26–28, and two slots for threaded joint with other similar universal modules. In addition MP 17–19 and 20–22 may contain CCD and LED arrays docking system.

SP 9 lower platform includes grooves with thread for articulation with other similar modules and CCD docking system.

SP 10 upper platform includes grooves with thread and an array of LEDs docking system.

SM5 SEMS module has the same advantages and disadvantages as the hexapod, but unlike hexapod provides not only the shifts and turns of the upper platform, but also the compression and expansion of the upper and lower platforms. This, together with control systems, measurement and docking increases its versatility [4, 5].

Fig. 5 The design platform of module SM4 SEMS

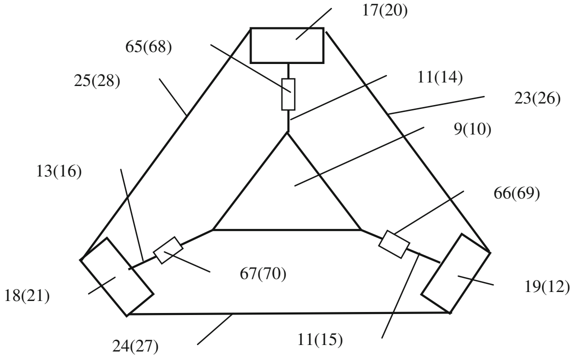


7 The Module SM6 SEMS

This module (see Fig. 7), in contrast to the module SM5 SEMS, has rods 29–31 and 32–34, which are mounted on the MP 17–19 and 20–22. They can be rotated in a plane passing through the points of attachment rods and center of the platform 1 and/or 2 perpendicularly to the latter, using of controlled drives 35–37 and 38–40. The rods 29–31 and 32–34 can change their length by means of linear control actuators 41–43 and 44–46. These rods make the module SM6 SEMS moved by their simultaneous turning and changing lengths. Sometimes the rods 29–31 and 32–34 can be elastic, which can be useful in medical robots.

SM6 SEMS module has the same advantages and disadvantages as the SM5 SEMS, but has a greater flexibility due to the ability to move in space with a simultaneous change of its size and turns.

Fig. 6 The circuit design of the module SM5 SEMS



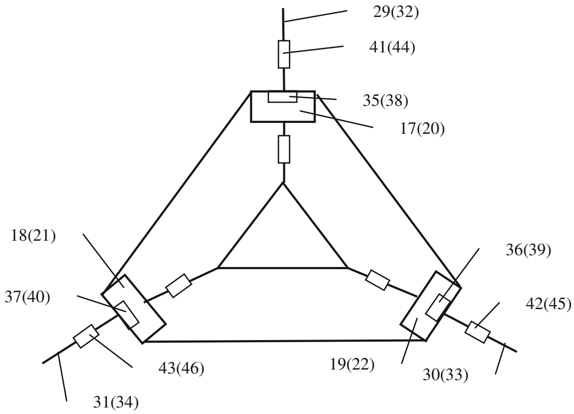


Fig. 7 The design platform of the module SM6 SEMS

8 The Module SM7 SEMS

Module SMS SM7 (see Fig. 8), unlike SMS module SM5, has the rods 47–49 and 50–52, which are mounted on the support plate 9 and/or 10 the platforms 1 and/or 2. They are directed inwards and can be rotated in the plane of the support areas 9 and/or 10 by means of controlled actuators 53–55 and 56–58. The rods 47–49 and 50–52 can change their length by means of linear control actuators 59–61 and 62–64. The latter can be used in the construction of the robot gripper as different objects. As in SM4 SEMS rods 47–49 and 50–52 may be elastic.

SM7 SEMS module has the same advantages and disadvantages as the SM5 SEMS, but has a greater flexibility by providing capture different subjects.

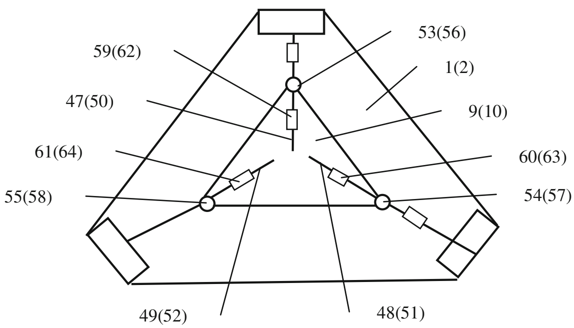


Fig. 8 Design platform of the module SM7 SEMS

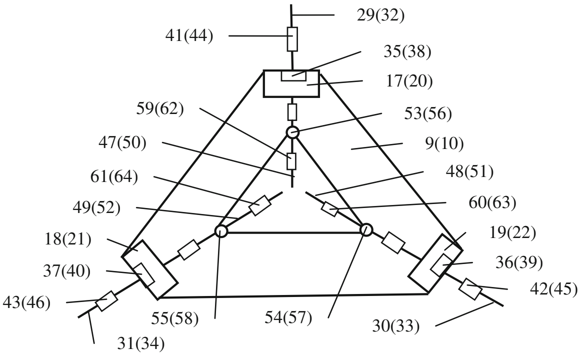


Fig. 9 The design platform of the module SM8 SEMS

9 The Module SM8 SEMS

This module (see Fig. 9), unlike the module SM5 SEMS, has rods 29–31 and 32–34, which are mounted on the MP 17–19 and/or 20–22 platform 1 and/or 2. They can be rotated in a plane passing through the points of attachment rods and center of the platform 1 and/or 2 perpendicular to the latter by means of a controlled drive 35–37 and 38–40. The rods 29–31 and 32–34 can change their length by means of linear control actuators 41–43 and 44–46.

Additionally, this module further has rods 47–49 and 50–52, which are mounted on the support plate 9 and/or 10 the platforms 1 and/or 2. They can be rotated in the plane of the support areas 9 and/or 10 by means of controlled actuators 53–55 and 56–58. The rods 47–49 and 50–52 inwardly directed platform (Fig. 9), and can change their length by means of linear control actuators 59–61 and 62–64.

SM8 SEMS module has the same advantages and disadvantages as the SM5 SEMS, but has a greater flexibility due to a combination of additional features and modules SM6 SEMS SM7 SEMS.

10 Conclusion

There is quite a large variety of standard models of SEMS, on the basis of which it is possible to design a variety of intelligent robots with parallel architecture type of SEMS. Modules such as a tripod have now limited the use of simple designs for a number of inherent weaknesses. Most have full functionality module SM8 SEMS and it can be called a universal module. The other modules are in some of the simplification. It is therefore advisable to study and construction of mathematical models, especially the module in order to study the characteristics and properties discussed SEMS standard modules.

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