Research and Development of Photovoltaic Module Intelligent Cleaning Robot

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Abstract. Serious stains on the surface of photovoltaic modules will affect the efficiency of power generation and may cause fire. Therefore, the cleaning must be clean and thorough. If the dead corner is left, it may cause "hot spot effect" and other serious consequences. The effect of photovoltaic module surface fouling on power generation efficiency is quite significant. Firstly, the surface turbidity affects the light transmission rate, and then affects the radiation amount accepted by the module surface; secondly, the dirt adheres to the surface of the panel and forms shadow, which produces hot spot effect in the local part of the PV module, thus causing damage to the PV panel, affecting the power generation rate and shortening the life of the PV panel. This process will aggravate the aging of the battery panel, reduce the output, and even cause a fire in serious cases. Photovoltaic cleaning robot is a new thing. In recent years, it has been highly concerned by the majority of photovoltaic power plant owners and photovoltaic enterprises. Photovoltaic cleaning robots can not only tell stories. However, it is necessary to realize the unattended periodic cleaning, intelligent dust removal and snow removal of photovoltaic modules through low cost and high reliability, and improve the efficiency of cleaning dust on the surface of photovoltaic panels by using intelligent cleaning robots, and thoroughly remove the dust and dirt on the surface of photovoltaic panels, so as to improve the power generation efficiency. Extend the service life of photovoltaic power station. This is a real practical photovoltaic cleaning robot[1].

Keywords: Photovoltaic Modules, Intelligent Robot, Research, Development

1. It has self-contained energy storage without external power supply
According to the particularity of photovoltaic modules, the system should be equipped with solar power generation, charging and storage devices, which can be self powered. The photovoltaic panel cleaning robot does not need to provide external power supply, and can start and stop at any time according to the needs. Solar energy is not only primary energy, but also renewable energy. It is rich in resources and can be used free of charge, without transportation and without any pollution to the environment. Solar power supply system does not need water, oil, steam, fuel, etc. to participate in the work of power generation, as long as there is light can generate electricity, is a clean, pollution-free
renewable energy, and simple installation and maintenance, long service life, can realize unattended.

Sunlight is a kind of radiation with wave particle duality. When the sunlight irradiates the matter, the energy carried by the solar photons can be transferred to the electrons, so that the electrons have higher energy (which can be compared with the phenomenon that the cue ball collides with other balls to make other balls move when playing billiards). When materials exist in isolation, the excited electrons have no other way to release energy, and can only convert their own energy into the internal energy of the material itself. That's why materials get hot when exposed to sunlight. By using this way, solar power generation has no mechanical transmission parts, simple operation and maintenance, stable and reliable operation, coupled with the wide use of automatic control technology, realizing unattended, low maintenance cost, creating a new life form for human beings, making society and human beings enter an era of energy saving and pollution reduction, which is the leader of new energy[2]. According to the electric load capacity, it can be large or small, convenient and flexible, and easy to combine and expand. With the wide application of automatic control technology, it can be basically unattended, which makes the maintenance cost of intelligent cleaning robot powered by solar energy low.

![Diagram](image)

**Figure 1.** Working principle of self-storage intelligent robot.

2. **Intelligent control. No one on duty to save labor cost**

With the development of robot technology, for the physical objects that can not be accurately analyzed and modeled and the ill conditioned process with insufficient information, the traditional control theory has exposed shortcomings. In recent years, many scholars have proposed various intelligent robot control systems. Multi sensor information fusion technology is a very popular research topic in recent years. Through the cooperation of IO control and motor control, motion control, communication management, spatial coordinate planning, map planning, security control and artificial intelligence[3]. Through a continuous rotating laser probe, the distance between the robot and the environment is measured to achieve positioning. The biggest drawback of this positioning system is that the probe is expensive, and the vSLAM image displacement positioning system needs to be continuously rotated when working: through the cleaning robot equipped with high-definition camera, the deviation of optical original image changes positioning coordinates, if the characteristic information or geometric shape of the reference object is fuzzy, the positioning accuracy will be
affected, so as to realize the front position on the photovoltaic module. After, high and low dislocation, long-distance cross row cleaning work, cleaning distance up to 2000 meters, suitable for various photovoltaic power plants. In addition, according to the different installation methods on site, the cleaning machines of photovoltaic power station also need different machines corresponding to each other. Generally speaking, they are all designed to improve the power generation.

3. Water free, clean, energy saving and environmental protection

In recent years, Gansu clean energy has developed rapidly, among which the photovoltaic industry is more attractive. However, with the development of the industry, the clean problem of solar photovoltaic panels has gradually attracted attention. In order to deal with the intelligent cleaning of photovoltaic modules in all environments, the intelligent cleaning robot of photovoltaic modules should be based on the principle of no water cleaning and energy saving\(^4\). On this basis, the intelligent robot can use wheeled mobile carrier, equipped with full hydraulic drive system, distance sensing path planning system, joint arm automatic control system, dust removal brush adaptive adjustment and automatic cleaning system, GPS intelligent tracking and positioning system, etc., so as to truly realize water-free cleaning. Large scale solar photovoltaic panel cleaning in the western region of water shortage can play a greater economic and social benefits, so as to effectively enhance the ability to prevent drought. Short term water-saving measures can bring immediate effect, while long-term water-saving can greatly reduce the consumption of water resources, thus improving the ability of drought prevention in normal period\(^5\).

![Figure 2. Photovoltaic module intelligent cleaning robot.](image)

4. Conclusion

At present, there are still some insurmountable problems in photovoltaic module intelligent cleaning robot. When the tilting of the cleaning robot leads to excessive positive pressure of the guide wheel and insufficient ability of the walking wheel to overcome obstacles, it is prone to "self-locking". In order to solve this problem, a possible solution is: through the establishment of equilibrium equation of space force system, optimize the distribution of brush density, length, and hardness, wheel diameter and spacing, number of guide wheel, spacing and diameter, as well as the size of the robot frame, drive motor parameters such as output torque, supplemented by the motor control algorithm, perception and timely adjust to walk round state, avoid to produce "locking". Intelligent cleaning robot does not need human intervention, and can automatically complete various anthropomorphic tasks in various environments. In this way, the ontology of autonomous robot has modules of perception, processing, decision making and execution, and it can act and deal with problems independently just like an autonomous person. For the current market research and development, after
that, the research and development direction of photovoltaic module intelligent cleaning robot should focus on the lightweight design, parts selection, driving mode and algorithm, charging mode, obstacle breaking algorithm and other aspects. So that it is constantly improved, more mature attitude applied in the photovoltaic module cleaning.

In recent years, with the development of emerging industries such as photovoltaic power generation, navigation and positioning, such as the development of intelligent robots are also constantly updated, our research and development of photovoltaic intelligent robot should also pay attention to visual sensing the core module, navigation and positioning algorithm based on camera constantly improve (software), combined with the camera research and development manufacturing module mature (hardware), scale of cost is reduced, more focus on the industry industry the development of new technologies, will continue to explore more new technology in the application of service robot industry may photovoltaic development, Gradually realize the application of intelligent service robot. Through the market survey, photovoltaic intelligent cleaning robot research has made big progress, are gradually formed industry, has increasingly wide application range, the overall control, intelligent sensor, integrated and intelligent navigation positioning communication after further mature and development, the key techniques such as photovoltaic intelligent cleaning robot will be more intelligent, reliable and practical, in pv and other fine instrument cleaning and other fields will have a more broad application prospects. There is no doubt that photovoltaic cleaning robot plays an important role in the continuous development of solar photovoltaic power generation\cite{6}. At present, the photovoltaic intelligent cleaning robot in China is still in the stage of gradual improvement, development and experiment, and many key technologies have not yet made breakthroughs, and there is still a long way to go from actual use. Therefore, we should seize the opportunity, innovate, and strive to have more independent technologies in the field of photovoltaic module intelligent cleaning robot.

\begin{figure}
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\caption{Experimental parameters of photovoltaic intelligent cleaning robot.}
\end{figure}

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