Robotics Applications in Asteroid Mining

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Introduction

The mining industry is both extremely valuable, and extremely important to modern life. As of April this year, the 50 highest valued companies in the mining industry are valued at a total of around $1.6 trillion USD, a number that is set to increase in the coming years. This is because mining, specifically that of metals, is crucial to everything in our society, being integrated into nearly every industry. Metals are used to make equipment used anywhere from farming, to fashion, to construction, however modern mining practices can be very detrimental to the environment. Mining can cause things like habitat loss, and water pollution in areas, usually third world countries, polluting the environment, and harming the Earth as a whole. In addition, the resources we are harvesting on Earth are limited. Asteroid mining fixes many of these problems. Our solar system is full of metals stored in asteroids, providing a practically unlimited well of resources we need only to discover the means of tapping into. It may not be viable with today's technology, but applying robotics to export mining off–world would help to not only increase the availability of key resources, but also allow the environment to heal in many countries where heavy mining has polluted the land and the water.

The Mining Industry

The real harm from the mining industry comes from the water use, mining tailings, the mine itself, and greenhouse gas emissions. Water is crucial in most mining for multiple reasons. First, it is often sprayed while material is being mined to take toxic dust out of the air. This helps the contaminants not blow downwind and settle in populated areas, however this does lead to a large amount of contaminated water, and runoff from this practice can damage ecologies and human settlements alike, as the chemicals and other waste in the runoff can damage most living things. In addition, high water use in areas with a limited access to freshwater can cause water stress in the region, causing droughts and subsequently famines.

Mining tailings are also a major source of pollution, and while there have been efforts made in the industry to cut down on the toxicity of these tailings, it can still prove harmful to the environment around where it is stored. Mining tailings refers to the waste produced after the desired minerals and metals are extracted, and oftentimes this waste is radioactive, toxic, and/or acidic. These tailings are contained by dams, and while this prevents most of the environmental damage, it does provide the risk of a dam break or overflow, which would be disastrous.

The creation of mines themselves can cause a wide variety of issues, depending on the type of mine it is. Open pit mining is very common, and consists of the digging of a large pit, from which ore is extracted and refined. This can be harmful because this mining process creates a lot of toxic tailings, and it also creates asbestos–like dust during the mining process. Tunnel

mining has a similar mining impact to open pit mining, but carries the additional risk of the mine collapsing. In Situ Leach (ISL) mining uses an acid to dissolve rock, where it is then pumped out and refined, and while it has a much smaller environmental impact compared to the previous two types, the strong acid used in this process can leak out and contaminate the local soil.

Greenhouse gas emissions during the mining process originate from two primary sources. First, clearing land to build the mine as well as the infrastructure to get to and from it causes the release of primarily CO2, and more importantly hurts the local environment's ability to release CO2. The second is that most of the machines used to extract, transport, and process material use gasoline or some other fossil fuel, leading to a high amount of carbon emissions.

While strides have been made to reduce the impact of the mining industry, it will still inevitably have some effect, and so being able to export this process off of Earth would allow for the environment in resource–rich areas to heal, and would help us fight the larger issue of climate change.

Benefits of Asteroid Mining

Mining in space carries a wide array of benefits. Firstly, the aforementioned pollution that can prove to be an issue on our planet currently would be all but eliminated, as the materials could be extracted and separated in space. This would leave only the transportation and further refinement processes to do on earth, which would carry a significant decrease in environmental harm after the infrastructure to accomplish such a feat is established. Additionally, according to the BBC, some estimates say that ~12,000 people are killed from mining accidents each year, something that would be eliminated if this idea were to be applied, because robots would do all of the dangerous work normally carried out by humans. The final major benefit comes in the availability of resources in space. While we do not have an exact estimate for the total value of metals and other minerals held in the asteroid belt, we know that they are immense. The asteroid 16–Psyche, for example, reportedly contains around $700 quintillion USD in gold, which reflects how truly plentiful bodies besides the Earth are.

Drawbacks of Asteroid Mining

While the benefits are immense, there are a few drawbacks that should be considered also. The major one is the economical development of third world countries. Developing African nations like Botswana rely on the mining industry, as without it much of their population would be unemployed, and their economy would be significantly damaged as 16.7% of their GDP comes from the mining industry. Many of the nations that rely on resource extraction do not have the technological means to get into space mining, and so they would be left behind as other more powerful nations grow more wealthy. Another major concern would actually be how plentiful the resources are. With elements from gold to hydrogen being so abundant, a large influx of these resources would cause many materials to lose much of their value, with one model from Tel Aviv predicting that if asteroid mining were to become a viable option for the collection of resources, the value of gold would fall 50%. This means that the resources would likely have to be introduced slowly, as a sudden flooding of the market could cause drastic changes in the market.

The Application of Robotics in Asteroid Mining

Now that the impacts have been analysed, how would this process actually work? There are a few different methods that could be used. The first is the mining satellite attaches itself to the asteroid, and extracts the resources in the asteroid belt before returning to Earth. The other is that the satellite latches on to the asteroid and then brings it into Earth's orbit, before resources are extracted from there. There are pros and cons with both methods. The first method would be more costly, but also much safer. The satellite would have to be more robust, with the optimal method of construction being its construction in near–Earth orbit before it heads to its destination. Once it is there it could use robots to extract resources from the target asteroid, and separate it into different minerals and other metals by using a method like a spinning drum to sort by weight. Then a module could be detached carrying the resources back to Earth, where they could be refined and then sold. The primary risk that this method carries is to the mining satellite itself, and the resource extraction could cause the asteroid to become unstable, and if the body were to collapse it could damage or even destroy the satellite. The other method could be more risky, but cheaper. It would entail a smaller satellite travelling to an asteroid, capturing it, and propelling it back to earth, where it could be put into orbit. From there, smaller robotic mining satellites could be sent up and extract resources much closer to home. This method has the benefit of being able to have a facility or swarm of satellites in orbit around Earth that could be repeatedly used for the mining of the asteroids, meaning that most of the investment would be close to home and easier to protect and maintain. However, this carries one major risk. If the artificial orbit were to be incorrectly calculated or maintained, the asteroid could fall into the Earth, which could carry any amount of harm depending on its size. Additionally, depending on the size of the object, it could have a major effect on the orbits of other satellites, the ISS, the moon, and any other objects around earth that would have to be accounted for.

The Application of Robotics in Asteroid Mining

Earth is our only home, and so it is imperative that we protect it. Mining is vital to our society, and so it is imperative that we are able to export it off–world, for the perpetuation of our society, and the protection of Earth. Right now it pollutes our environment, making life inhospitable in many places, all the while contributing to soil erosion and global warming. Additionally, the resources on Earth are limited, and so there will come a time where mining on Earth for many metals no longer becomes feasible. Robotic–assisted asteroid mining would allow us to gain access to a large amount of valuable materials in nearly unlimited quantities, allowing humanity to continue to develop without the risk of running out of some key resources, and further damaging the environment in the process. It also carries a high monetary incentive as well, as asteroid mining would no–doubt become one of the most valuable industries should a company attain the capability to accomplish such a feat. While there would be some issues introduced as a result of the introduction of asteroid mining, they can be solved, and are far outweighed by the necessity of it. The future of our society lies in robotic–assisted asteroid mining, should we be able to achieve it.

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