

## **ROBOTS SECURITY & BLOCKCHAIN SWARM**

Consensus achievement is a crucial capability for robot swarms, for example, for path selection, spatial aggregation, or collective sensing. However, the presence of malfunctioning and malicious robots can make it impossible to achieve consensus using classical consensus protocols. In this work, we show how a swarm of robots can achieve consensus even in the presence of Byzantine robots by exploiting blockchain technology. Bitcoin and later blockchain frameworks, such as Ethereum, have revolutionized financial transactions. These frameworks are based on decentralized databases (blockchains) that can achieve secure consensus in peer-to-peer networks. We illustrate our approach in a collective sensing scenario where robots in a swarm are controlled via blockchain-based smart contracts (decentralized protocols executed via blockchain technology) that serve as “meta-controllers” and we compare it to state-of-the-art consensus protocols using a robot swarm simulator. Additionally, we show that our blockchain-based approach can prevent attacks where robots forge a large number of identities. The developed robot-blockchain interface is released as open-source software in order to facilitate future research in blockchain-controlled robot swarms. Besides increasing security, we expect the presented approach to be important for data analysis, digital forensics, and robot-to-robot financial transactions in robot swarms.

Swarms of robots will revolutionize many applications, from targeted material delivery to farming. However, the characteristics that make them ideal for certain future applications, such as robot autonomy or decentralized control, can also be an obstacle when transferring this technology from academia to real-world problems. Blockchain, an emerging technology, demonstrates that by combining peer-to-peer networks with cryptographic algorithms, a group of agents can reach agreements without the need for a controlling authority. The combination of blockchain with other distributed systems, such as robotic swarm systems, can provide the necessary capabilities to make robotic swarm operations more secure, autonomous, flexible, and even profitable.

## **HOW BLOCKCHAIN COULD MAKE ROBOT SWARMS SMARTER**

The robots are coming, and they're getting smaller, smarter and cheaper.

While today, businesses may own just a single drone, one day, large parts of whole industries could be overseen by a new generation of robots. But, how will groups of these robots perform useful tasks like collecting crop data or organizing around a common goal?

The eight-year robotics veteran believes that by using the blockchain to distribute information, whole armies of robots could solve problems and accomplish tasks more efficiently.

The idea is that in robotic swarms, each robot follows basic rules, drawing inspiration from creatures like ants and fish that often clump together. These small rules then add up to collective behaviours, such as distributed sensing or search-and-rescue missions, that emerge as a result of the interactions between robots.

So far, these ideas haven't been deployed on a large-scale. But researchers have high hopes for use cases such as so-called "precision farming," where fleets of drones could be used to inspect crops and paint a more granular picture for farmers.

As researchers are moving forward with this futuristic idea, they're facing many security and logistical problems that have prevented robot swarms from moving from research labs to the real world. The blockchain could lead to "serious progress" in swarm robotics.

"The combination of blockchain with other distributed systems, such as robotic swarm systems, can provide the necessary capabilities to make robotic swarm operations more secure, autonomous, flexible and even profitable."

Applying bitcoin to robotics has been theorized before for autonomous networks of driverless cars or drones that would deliver packages.

But this is different; the white paper sketches a blockchain-based system where robotic "nodes" organize in a secure, distributed way. One potential role for the

**blockchain is to help the robotic groups to come to agreement about a decision without a central authority.**

**It outlines a model where the robotic swarms use the blockchain by serving as nodes in a network and “encapsulating their transactions in blocks”. Blockchain-based applications described in the white paper include secure communications between robots, distributed decision-making, behaviour differentiation and new business models.**