Securing Global Food: Biopolymers, Cryptography, and Visual Transformers for Affordable Anti-Counterfeit Seed Protection

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According to the World Bank, ~50% of the seeds sold in Africa are counterfeit. Exhibiting lower germination rates, fake seeds cost farmers up to two-thirds of their crops, and, exacerbated by climate change, lead to global food shortages, starvation, and political unrest. The issue stems from the inability to trace seed distribution chains and differentiate genuine seeds from counterfeit ones. A promising new idea suggests marking seeds with biopolymer tags, but their verification requires a costly Raman spectrometer and an Internet connection, posing obvious obstacles for smallholder farmers. This project proposes an affordable anti-counterfeit seed protection system combining biopolymer tags, cryptography, and visual transformers. The system aims to provide cost-effective counterfeit detection for farmers and seed manufacturers, ensuring that the verification process is swift and reliable, and tolerates intermittent Internet access. The system consists of three components: identification of a unique, unclonable biopolymer tag by a novel algorithm (Visual Transformer), verification with a cryptographic signature, and a public blockchain to trace ownership-changing transactions. All steps can be done on a smartphone or another inexpensive computing device. I have built a prototype with Raspberry Pi. With my original pre-training method, the algorithm reached 100% accuracy in identifying biopolymer tags. According to my statistical analysis, the approach reduces the share of counterfeit seeds from 50% to 6.6% if only 5 seeds per bag are checked, and to 3.5%, with 10 seeds. Adding the blockchain further reduces the expected share of undetected counterfeit seeds to 0.05% or 0.005%, respectively.