Tropentag, September 10-12, 2025, hybrid conference

"Reconcile land system changes
with planetary health"

Smart control of mechanical oil pressing using deep reinforcement learning

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Abstract

Ensuring reliable and efficient operation of solar-powered agro-processing equipment in off-grid settings remains a critical challenge in rural development. Productive use of solar energy is often critical where efficient and continuous operation are necessary. This work presents a novel controller for a standalone, photovoltaic-driven mechanical oil press based on Deep Reinforcement Learning (DRL). Previous work was leveraged to develop a MATLAB/Simulink model of a PV powered mechanical press of peanut oil that served as training environment. A DRL agent was defined to observe seven variables (hour, month, PV power, battery state of charge, weekly irradiation, and previous action), and its action space consisted of discrete press speeds (0–70 rpm). A composite reward function incentivized continuous oil yield, minimised battery cycling and power interruptions. Training was performed using 15 years of weather data from PVGIS-SARAH2 database and included an adversarial phase on the 5 % least-sunny days to enforce robustness under low-irradiance conditions. In silico validation showed stable average rewards and simulated daily throughput of 96 ± 13.5 kg under sunny days and 90 ± 20.5 kg under cloudy days. The learned strategy was embedded on an ESP32 microcontroller and interfaced with a Kern Kraft KK20 press and a laboratory PV simulator for experimental validation. On a sunny test day, the DRL controller extended operation from 10 h to 14 h, processed 128 kg of seeds (vs. 130 kg), increased oil output by 2 % (39 to 40 kg), with an increased energy use of 12 %. On a cloudy day, interruptions fell from multiple outages to a single shutdown, with pressing duration increased from 5.6 to 8 hours. In both cases, oil yield increased by 4 % with increased specific energy ensuring best use of solar energy available. These results demonstrate that PV-sensitive DRL control can significantly enhance operational uptime, energy efficiency, and robustness of off-grid oil-pressing systems. Future work could investigate could explore temperature-based control of the mechanical press, seasonal reward shaping, and multi-objective optimisation to tailor policies for different crop types or economic priorities.

Keywords: Mechanical oil extraction, plant oil, process simulation model, reinforcement learning, renewable energy, smart control, solar energy

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