UAV'S LANDING ON A MOVING PLATFORM

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Unmanned aerial vehicles (UAVs) are increasingly being used in maritime operations, including environmental monitoring, reconnaissance, cargo delivery, and search and rescue missions. One of the key challenges in deploying UAVs in maritime environments is ensuring precise and safe landing on moving platforms, such as helicopter decks of ships. The main difficulties associated with landing UAVs on a rocking platform include:

1) constant displacement of the landing point due to the vessel's motion [1];
2) the impact of wind disturbances on the UAV's trajectory;
3) the need to account for the structural features of the platform or ship to prevent collisions and mechanical damage.

Landing a UAV can be performed either manually or automatically. In robotics, reinforcement learning is widely used to automate such tasks – a machine learning method that enables software to make decisions to achieve optimal results [2]. This method is based on the principle of trial and error, similar to the human learning process. Within the scope of this research, deep learning methods are proposed for automating UAV landing.

The process of automatic landing on a platform can be divided into two main stages: approach to the platform and the actual landing.

During the approach stage, the UAV is controlled using machine vision algorithms. For this purpose, the UAV is equipped with a forward-facing camera and an onboard computer. The UAV detects the landing platform and begins moving toward it. This stage is completed when the UAV is positioned directly above the platform. To improve positioning accuracy, it is proposed to place visual markers on the platform. Such markers can include two-dimensional "AprilTags", which are black-and-white squares resistant to distortions, lighting changes, and partial obstructions [3].

During the landing stage (fig. 1), the UAV descends smoothly, aligning itself with the center of the marker using a nadir-facing camera. To implement this stage, deep reinforcement learning agents, such as Deep Q-Networks (DQN) and Proximal Policy Optimization (PPO), are proposed [4]. These agents are expected to be deployed on the onboard computer and pre-trained in a simulated environment, ensuring high precision and reliability of landing even in challenging maritime conditions.

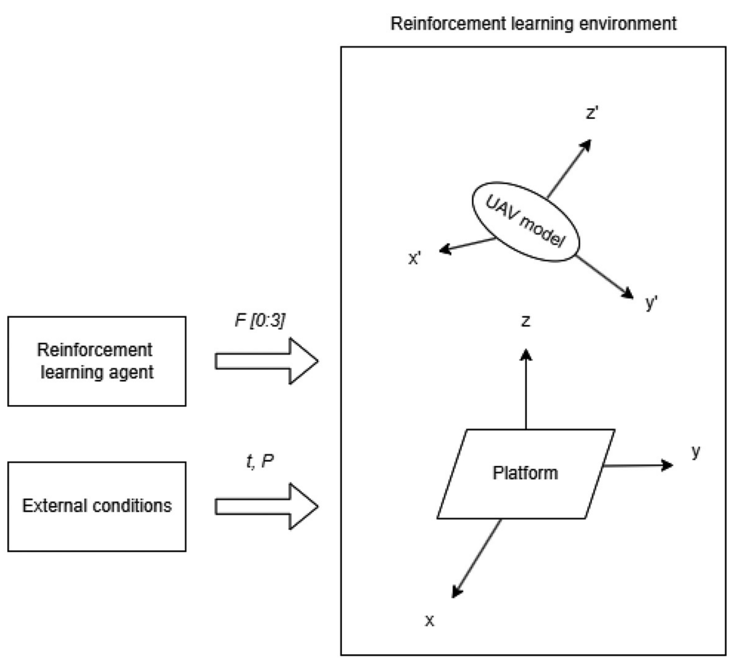

Fig. 1. Automatic landing of the UAV on a moving platform

This work is dedicated to the development of a simulation environment for UAV control aimed at training reinforcement learning agents. Strategies for the agents, transition functions, and reward functions are proposed. The motion of the platform within the environment is described using the empirical JONSWAP wind wave spectrum model [5]. The platform is modeled as a rectangular plate; in addition to the force of gravity, each of the four edges of the platform is subjected to a buoyant force dependent on wave height and a predefined coefficient. The dynamic model of the aircraft – a fixed-wing glider with four rotors for vertical takeoff and landing – was developed based on data obtained during a year of operating short-range UAVs. The model accounts for aerodynamic drag forces. Agents trained using the proposed methodology can be deployed on an onboard computer and will enable the automation of vertical UAV landing on a rocking platform in maritime conditions.

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