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Design of a Human-in-the-Loop Aircraft Taxiing Optimisation System Using Autonomous Tow Trucks

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Abstract : The need to reduce fuel and noise during taxi operations in the airports with a scenario of constantly increasing air traffic has resulted in an effort by the aerospace industry to move towards electric taxiing. In fact, this is one of the problems that is currently being addressed by SESAR JU and two main solutions are being proposed. With the first solution, electric motors are installed in the main (or nose) landing gear of the aircraft. With the second solution, manned or unmanned electric tow trucks are used to tow aircraft from the gate to the runway (or vice-versa). The presence of the tow trucks results in an increase in vehicle traffic inside the airport. Therefore, it is important to design the system in a way that the workload of Air Traffic Control (ATC) is not increased and the system assists ATC in managing all ground operations. The aim of this work is to develop an electric taxiing system, based on the use of autonomous tow trucks, which optimizes aircraft ground operations while keeping ATC in the loop. This system will consist of two components: an optimization tool and a Graphical User Interface (GUI). The optimization tool will be responsible for determining the optimal path for arriving and departing aircraft; allocating a tow truck to each taxiing aircraft; detecting conflicts between aircraft and/or tow trucks; and proposing solutions to resolve any conflicts. There are two main optimization strategies proposed in the literature. With centralized optimization, a central authority coordinates and makes the decision for all ground movements, in order to find a global optimum. With the second strategy, called decentralized optimization or multi-agent system, the decision authority is distributed among several agents. These agents could be the aircraft, the tow trucks, and taxiway or runway intersections. This approach finds local optima; however, it scales better with the number of ground movements and is more robust to external disturbances (such as taxi delays or unscheduled events). The strategy proposed in this work is a hybrid system combining aspects of these two approaches. The GUI will provide information on the movement and status of each aircraft and tow truck, and alert ATC about any impending conflicts. It will also enable ATC to give taxi clearances and to modify the routes proposed by the system. The complete system will be tested via computer simulation of various taxi scenarios at multiple airports, including Malta International Airport, a major international airport, and a fictitious airport. These tests will involve actual Air Traffic Controllers in order to evaluate the GUI and assess the impact of the system on ATC workload and situation awareness. It is expected that the proposed system will increase the efficiency of taxi operations while reducing their environmental impact. Furthermore, it is envisaged that the system will facilitate various controller tasks and improve ATC situation awareness.

Keywords : air traffic control, electric taxiing, autonomous tow trucks, graphical user interface, ground operations, multi-agent, route optimization
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