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Extended Abstract

Hierarchical coordinated control distribution and experimental verification for six-wheeled unmanned ground vehicles

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Abstract

In recent years, the all-wheel independent drive has been the most promising form of drive configuration in unmanned ground vehicles. Considering the difficulties in the control allocation for this kind of vehicle, this paper presents a hierarchical control coordination strategy with three layers to distribute control in real time effectively and accurately. In the upper layer, a hybrid instruction parsing method is proposed, which converts commands of the control panel into driving force requirement and target steering yaw rate, respectively, to prioritize steering command to maintain the trajectory based on the motor properties. Subsequently, a sliding mode controller is employed to convert the target yaw rate into the required yaw moment. The state estimation layer receives data from the sensors and estimates different properties/ parameters required in other layers. The lower-level control layer receives commands from the upper layer and allocates respective control to wheels. The control allocation problem has been formulated as an optimization problem and later has been converted into a quadratic programming problem, in which a novel modified barrier method with the combination of reduced equation dimension has been adopted to minimize the computational effort and complexity for implementation on the embedded platform. Computer simulation and field experiment have been conducted, which verify the performance of the proposed strategy. The unmanned ground vehicle (UGV), a driverless vehicle platform, is favored in many practical situations that are dangerous, difficult, or inconvenient for the presence of human drivers onboard. The general components of a UGV are a variety of sensors for information of the surrounding environment, control unit to process it and make a decision, and a wireless communication system for monitoring. The UGV can be used in a variety of applications for civilian or military uses such as explosive handling, landmine and bomb detection, surveillance and reconnaissance purpose, combat vehicles, agricultural vehicles, mining vehicles, manufacturing and production automation, and so on. UGV is also being used in search and operations in disaster areas to minimize human casualties.

In recent years, the effect of global warming, rising pollutions level, shortage of non-renewable energy has triggered the automobile industry to shift toward research and development on the electric vehicle (EV) as a future vehicle. In addition, clean energy and zeroemission regulations have catalyzed the diversion toward this sector. Ongoing research advancement in the field of battery technology, motor drives, and controllers, and other supporting accessories have led toward increment in numbers of EVs being produced day by day in contrast to earlier production rates. EVs have been a central research topic because of its numerous benefits over conventional fuel vehicles in terms of pollution, vibration, sustainability, and so on. With a demand of optimizing the vehicle overall size and power losses, all-wheel independent drive (AWID) architecture, a pure EV with novel vehicle drive configuration, appeared eliminating the use of conventional transmission system, differential drivetrains, assisted by the development of sophisticated driveline strategy and is expected to be a popular future drive configuration.1–4 The all-wheel-drive configuration is possible because of the ability of the motor to generate desired torque sharply and accurately with ease of measurement. In fact, the first vehicle on the moon, the Lunar Rover,5 had in-wheel motors with the novel AWID configuration. With the advancement in drive and motor technologies, the UGVs are being designed with electric motors for silent operation, fewer heat signatures, and so on. The in-wheel motor drive has numerous advantages over conventional axle drive. It can make the vehicle structure compact by minimizing the suspension space and yield all-terrain drive capability due to the differential steering (skid steering) mechanism. With the in-WID, the vehicle can be used in a variety of applications with intense maneuvering as it can combine the functions of ABS (anti-lock braking system) and TCS (traction control system). Such features of in-wheel drive make it very suitable for use in the defense area.

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