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DEVELOPMENT OF A TORQUE VECTORING SYSTEM FOR FEST22 FORMULA CAR

Bachelor's thesis

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TORQUE VECTORING SÜSTEEMI ARENDUS FEST22 VORMELAUTOLE

Bakalaureusetöö

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Author’s declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Abstract

In this thesis, a torque vectoring system for Formula Student formula car was designed and developed. First, analysis on previous years system was conducted to provide reasoning for the torque vectoring system. A vehicle model was developed, followed by modelling the system in Simulink, implementing the model in C language and testing on the vehicle.

The torque vectoring system was implemented on a formula car with four separate DYNASYN DD5-14-10-POW-18600-B5 synchronous servo motors, one in each wheel. Two important sensors were used to measure the vehicle's state. A self-developed ground speed radar, that was not developed by the author of this thesis, and an SBG Series Ellipse-N inertial measurement unit.

A simplified vehicle model, often known as bicycle model, was developed to carry out simulations and calculate the yaw moment for the motors in the torque vectoring system.

The controller developed to track the yaw rate was tuned with step-response simulations and simulations on previous season's track data. C code was generated in Simulink using Embedded Coder application and was implemented on the electronics control unit on the vehicle.

Tests were carried out on the stands as well as driving the vehicle. On the stands, critical points were validated, such as the wheels not spinning backwards and the initial logic behind torque distribution. Driving the vehicle in the parking lot initially introduced a few problems which were addressed with tuning the controller and torque distribution. The system will be further developed throughout the season.

This thesis is written in English and is 29 pages long, including 7 chapters, 16 figures and 1 table.

Annotatsioon

Torque vectoring süsteemi arendus FEST22 vormelautole

Käesoleva töö raames arendati *torque vectoring* süsteem Tudengivormeli vormelautole. Esmalt analüüsiti eelmise hooaja mootorite juhtimise süsteemi lahendust ning toodi välja põhjused uue süsteemi disainimiseks. Süsteemi loomiskes arendati automudel, modelleeriti süsteem Simulink tarkvara abil ning implementeeriti C keeles auto tarkvarasse. Loodud süsteemi testiti seejärel vormelautol.

Torque vectoring süsteem arendati vormelautole, mida juhitakse nelja eraldiseisva DYNASYN DD5-14-10-POW-18600-B5 sünkroonse servo mootori abil, mis paiknevad nelja ratta sees. Auto oleku hindamiseks kasutati kahte olulist sensorit. Isearendatud *Ground speed radar*, mis mõõdab vormeli kiirust maapinna suhtes, ning mis ei ole arendatud töö autori poolt. Güroskoobi ning akseleromeetrina on kasutusel SBG Series Ellipse-N *inertial measurement unit.*

Töö raames arendati lihtsustatud auto mudel, mida kasutati süsteemi simuleerimiseks ning autole vajaliku z-telje ümber mõjuva momendi arvutamiseks.

Regulaatori parameetrite sätestamiseks viidi läbi hüppekaja simulatsioonid ning simulatsioonid eelmise hooaja testil kogutud andmetega. Süsteem genereeriti C koodiks, kasutades Simulink Embedded Coder rakendust ning implementeeriti mootorite juhtmooduli tarkvarasse.

Arendatud süsteemi testiti esialgu pukkidel ning hiljem autoga sõites. Pukkidel välistati kriitilised vead, mis võivad olla juhile auto roolis väga ootamatud ning valideeriti momendi jaotuse algoritmi. Vormelautoga sõitmisel esines üksikuid probleeme, mis lahendati esialgselt regulaatori parameetrite sätestamisega ning momentide jaotamise algoritmi muutmisega.

Lõputöö on kirjutatud inglise keeles ning sisaldab teksti 29 leheküljel, 7 peatükki, 16 joonist, 1 tabelit.