SIMPACK Biomotion driver and occupant models for single-track, multi-track and other vehicles

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agenda

• biomechanical human body models
• application as passive occupant
• application as active driver for single track vehicles
• application as active driver for multi-track vehicles
• conclusion & outlook
MODEL GENERATION
human body model in mbs

mass & inertia,

length, joint coordinates

17 x
A percentile (or a centile) is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall. For example, the 20th percentile is the value (or score) below which 20% of the observations may be found.
regression equations for segment length

segment length given by stature and coefficients

\[ l_s(l_0) = a_{sl} \times l_0 + b_{sl} \]

\[ \begin{align*}
  l_s & : \text{segment length} & [m] \\
  l_0 & : \text{stature} & [m] \\
  a_{sl} & : \text{coefficient of segment length} \\
  b_{sl} & : \text{offset of segment length} & [m]
\end{align*} \]
segment mass parameters

segment mass as function of total body mass and coefficients

\[ m_s(m_0) = a_{sw} \times m_0 + b_{sw} \]

- \( m_s \) : segment mass \( [kg] \)
- \( m_0 \) : total body mass \( [kg] \)
- \( a_{sw} \) : coefficient of segment weight \( \) [less than or equal to] \( 1 \)
- \( b_{sw} \) : offset of segment weight \( [kg] \)
human body models wizard of Biomotion Workbench

input parameters for model:

• stature
• weight
• gender

all necessary elements like joint actuators, wobbling mass elements or contact force elements are also generated by the model generator.

17 segments
5% female and 95% male

data can be found e.g. in: NASA (McConville und Laubach, 1978) und DIN (DIN, 1986).
application: passive occupant

- the generated models can be used as passive substructure in vehicle models
- e.g. shift comfort
- e.g. comfort & safety optimization for transport of injured persons
human as substructure in car model
Application: Shift comfort analysis
application: rescue & defense
application: rescue & defense
application: rescue & defense
application: rescue & defense

occupant: stresses and strains in nonstandard situations

Time = 00.02 s
Human & Dummy differ

ACTIVE MODELS
bicycle riding

- steering by handlebars movement
- propulsion by pedaling

the model

- bicycle model
- tire force model
- human body model
- motion control for handlebars
- motion control for pedaling motion
• control approach: road preview
• counter steering → ”steer into the fall“
• to control roll angle the steering angle has to be controlled
• the desired steering angle is input to Joint Space Model (JSM) controller (285 – Biomotion Motorcycle Rider)
handlebars control scheme
tire model: user element (class tire)

• SIMPACK user function
• force class tire force ("spck_df_ForceTire")

pedaling motion: user element (control)

- user element
- force class control element
- generates output for joint actuators (FEL 283: Biomotion Actuators)
6 DOF bicycle simulation
CEL 285: Biomotion Motorcycle Rider

- compatible to SIMPACK automotive
- generates output for joint actuators (FEL 283: Biomotion Actuators)
- velocity control: output moment front / rear wheel
- wheelie / stoppy (by pitch angle control)
CEL 285: Biomotion Car Driver

- compatible to SIMPACK automotive
- compatible to SIMPACK CEL 128
- generates output for joint actuators (FEL 283: Biomotion Actuators)
CONCLUSION & OUTLOOK
conclusion

• human body models can be generated by a model wizard (manual generation would be error-prune and costly)
• it is easy to include a human body model as substructure in existing SIMPACK models
• sometimes passive models are not adequate
• active driver models can be combined with existing vehicle models
outlook

• enhance the existing motion controllers
• extend the principle to other vehicles (boats, planes)
thank you for your time!

De motu animalium by Giovanni Alfonso Borelli (1608-1679)