MOPED

An agent-based model for peloton dynamics in competitive cycling

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Introduction

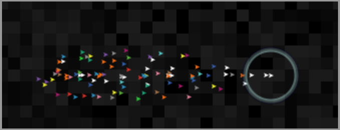
- Drafting as the basis for complex behaviours
- Mathematical, Physiological and Dynamical concepts
- First effort into an agent-based model of pelotons
- Main objective: consistency with real-life behaviour

Dynamical Parameters

- Inspiration from flocking models
- Only cohesion and separation forces apply to our model
- Lateral movement instead of steering
- Improvement - Swarm Chemistry model

From Swarm Chemistry to MOPED

- What to change?
- No isotropic vision - humans can't look back!
- Different scales of distance for different forces
- Bias to the center of the road
- Small random acceleration
- *Active* agents: small bias to the front



Energetic Parameters

- Well-know set of equations
- Abundant Physiological data
- Calculate energy expenditures
- Address both energy and dynamics

Draft Coefficient

- $CF_{draft} = 0.62 - 0.0104d_w + 0.0452d_w^2$
- "Comet's tail" effect
- Different weights for different angles
- Drafting is negligible for distances bigger than 3m

Power Equations

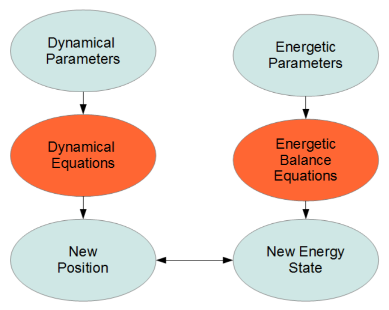
- $P_{air} = kCF_{draft}v^3$
- $P_{roll+PE} = (C_r + G_r)g(M + Mb)v$
- Constants k and C_r are from empirical data and have typical values
- Valid for relatively small values of G_r (smaller than 10%, typically)

Time to Exhaustion

- How to model the time it takes for a cyclist to run out of energy?
- $\ln(T_{lim}) = -6.351 \ln(\frac{P_{tot}}{Max_{10}}) + 2.478$
- Typical Max_{10} for professional cyclists: 450W
- Lactate Threshold as a measure of recovery
- Cyclists spending more than their LT power are using their "reserves"

Energetic Parameters

- Dynamical and Energetic model influence each other



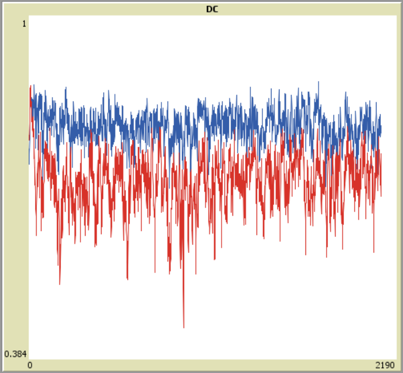
- Drafting coefficient and exhaustion as coupling factors

General Behaviour

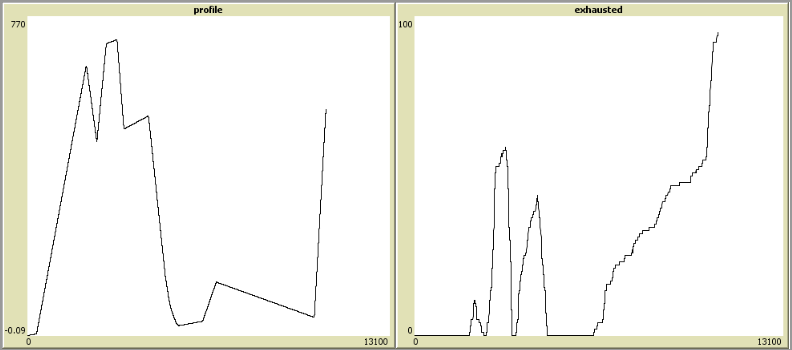
- Rotation when frontrunner feels under the peloton average
- Narrow front, wider back conform to real life
- Convection dynamics - see demo!
- Dissipative dynamics - Rayleigh-Bernard cells, penguin huddle rotations
- Relevant result in terms of energy without considering energy for dynamics!
- Active cyclists take over the head of the peloton
- Exhausted riders give up on the peloton, but can eventually come back

Dynamical Parameters

- Difficult to quantify
- General dynamics seem to conform to real life
- Convection dynamics shown graphically

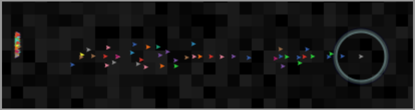


Simulated Race

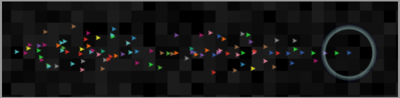


Uphills and Downhills

- The peloton arriving on top of a climb...

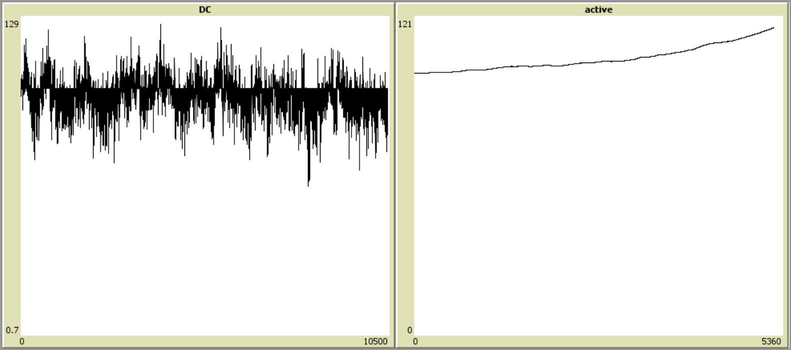


- and then during the downhill.



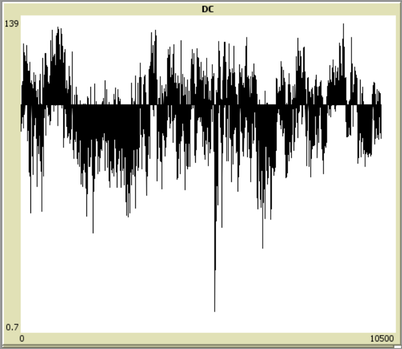
Active Cyclists - a paradox?

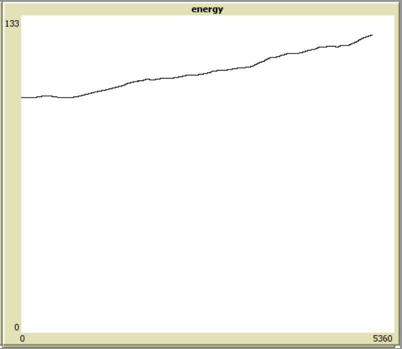
- Active riders are actually spending less energy - how is that possible?



Independence of number of active riders

- The same result holds for 5 active cyclists instead of 20.





Discussion

- Interesting, even counter-intuitive results
- Active cyclists problem: a bit worrying. However, model can be improved in that sense (look for draft)
- Many real-life factors are not present (e.g. wind)
- Strategical aspects were not modelled (unfortunately)
- First try ever to couple dynamics and energy expenditure analysis in one single model
- Not a complete work in any way, rather a first step