Features for F1 Autonomous Driver

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Given a set of laps, we use as *reference trajectory*, i.e., the trajectory we aim to learn, the best lap, and all the features of each trajectory are computed with respect to it. We can distinguish in four main classes of features: position, speed, acceleration and previous action. In addition to these classes there are other features.

Position features Position features are used to define how much the car position differs from the reference trajectory. Given a point p_t of the actual trajectory, be r_t the nearest reference point and r_{t+1} its consecutive. We build a new reference system with the x-axis on the vector $r_t r_{t+1}$ as in figure 1. From this new reference system we identify the following features:

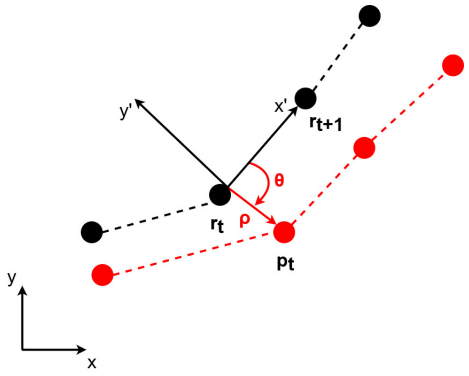

Figure 1: New reference system x',y' built using the vector $r_t r_{t+1}$ as x axis.

Curvature

- actual curvature: given the trajectory point p_t the actual curvature is the angle between the vectors $p_{t-1} - p_{t-2}$ and $p_t - p_{t-1}$. The angle is negative if the vector $p_{t-1} - p_{t-2}$ is on the right of the other;
- reference curvature: given the nearest reference point r_t of the trajectory point p_t, the reference curvature is the angle between the vectors $r_t - r_{t-1}$

and $r_{t+1} - r_t$. The angle is negative if the vector $r_t - r_{t-1}$ is on the right of the other;

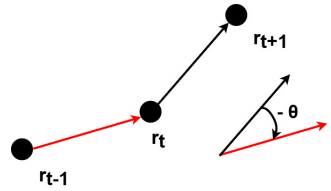

Figure 2: Curvature of reference point r_t.

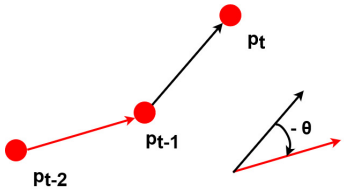

Figure 3: Curvature of trajectory point p_t.

- position x: x coordinate of p_t with the absolute reference system
- position y: y coordinate of p_t with the absolute reference system
- rho: module of the vector $r_t p_t$;
- theta: angle of the vector $r_t p_t$;
- reference x: x coordinate of r_t with the absolute reference system;
- reference y: y coordinate of r_t with the absolute reference system;
- relative x: x coordinate of p_t with the new reference system;
- relative y: y coordinate of p_t with the new reference system;
- position left: boolean, true if the point p_t is on the left of r_t;
- position right: boolean, true if the point p_t is on the right of r_t;

Speed features As for the position features, also the speed is represented relatively to the reference trajectory, we define $\vec{v}_{p_t}$ the speed vector with x,y components of the point p_t and with $\vec{v}_{r_t}$the speed vector with x,y components of the nearest reference point.

- actual speed module: module of the speed vector of $p_t \parallel \vec{v}_{p_t} \parallel$;

- speed difference vector module: module of the difference vector $\parallel \vec{v}_{r_t} - \vec{v}_{p_t} \parallel$;
- speed difference of modules: difference between the modules of the speed vectors $\parallel \vec{v}_{r_t} \parallel - \parallel \vec{v}_{p_t} \parallel$;
- reference speed angle: angle between the two speed vectors. The angle is negative if the vector $\vec{v}_{p_t}$ is on the right of $\vec{v}_{r_t}$, see 4

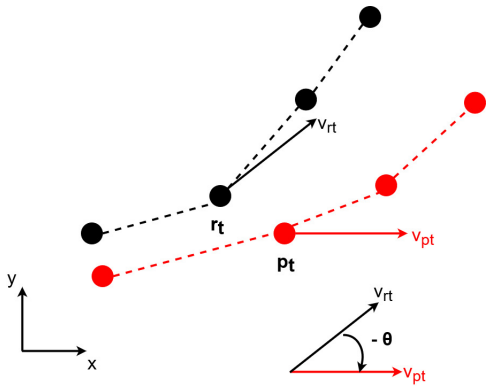

Figure 4: Angle between the speeds vectors $\vec{v}_{p_t}$, $\vec{v}_{r_t}$.

Acceleration features The acceleration features follow the same structure of the speed:

- actual acceleration module: module of the acceleration vector of p_t $\parallel \vec{a}_{p_t} \parallel$;
- acceleration difference vector module: module of the difference vector $\parallel \vec{a}_{r_t} - \vec{a}_{p_t} \parallel$;
- acceleration difference of module: difference between modules of the acceleration vectors $\parallel \vec{a}_{r_t} \parallel - \parallel \vec{a}_{p_t} \parallel$;
- reference acceleration angle: angle between the two acceleration vectors. The angle is negative if the vector $\vec{a}_{p_t}$ is on the right of $\vec{a}_{r_t}$.

Other state features Additional state features are:

- n engine: engine revolutions [rpm];
- n gear: actual gear;
- speed yaw: angular speed on the z axis.

Previous actions Previous actions are used as feature state

- Steer angle: angle of the steer wheel;
- brake: pression of the brake pedal;
- throttle: percentage of the throttle pedal;
- upshift request: request to change to the upper gear;
- downshift request: request to change to the lower gear.