Update - Kalman Filter

João Böger

Sprace

Outline

Semester summary

- QFT I - Prof. Gustavo Alberto Burdman at USP as non-degree student UNDERWAY

Research

- Particle Dark matter
  - Intro to Particle Dark Matter - Stefano Profumo UNDERWAY
- Standard Model
  - Intro to SM - S. Novaes UNDERWAY
- QCD
  - Introduction to QCD - P. Skands
- Tracking sequences
  - HLTIterativeTrackingIter02 DONE
  - Kalman Filter UNDERWAY
  - Add to HLT-Phase2's wiki on GitHub PLANNED

Kalman Filter Variables Definition

- x_t Predicted state estimate
- v_t Velocity
- Δt Time interval between two steps
- h_t Uncertainty of the predicted state estimate
- B Magnetic field (in $\hat{z}$)
- q Particle charge
- z_t Observation/measurement of the true state of x_t
- r_t Measurement uncertainty
- k_t Kalman gain
- x_t' Updated state estimate
- h_t' Updated variance of the state estimate
- m Particle mass

Kalman Filter Equations

Thus our Kalman filter will work as follows:

Prediction

$$\text{RK4 on the coupled ODE} \quad \vec{x}_t = (x_{r,t}, x_{\phi,t}), \quad \dot{\vec{x}}_t = (\dot{x}_{\dot{r},t}, \dot{x}_{\dot{\phi},t})$$

Update

$$k_t = \frac{h_t}{h_t + r_t} \qquad \text{(Kalman gain)}$$

$$\vec{x}'_t = \vec{x}_t + k_t(\vec{z}_t - \vec{x}_t) \qquad \text{(Updated state estimate)}$$

$$q'_t = p_t(1 - k_t) \qquad \text{(Updated uncertainty of the state estimate)}$$

Circle in Polar Coordinates

The **General equation of a circle in polar coordinates** with center at (r, φ_0) and radius R is given by

$$r^2 + r_0^2 - 2rr_0 \cos\theta - \varphi = R^2 \quad . \qquad (1)$$

Once we want a circle which intersects our origin we take $r_0 = R$

$$r^2 - 2rR\cos\theta - \varphi = 0$$

$$\theta = \varphi + \arccos\frac{r}{2R}$$

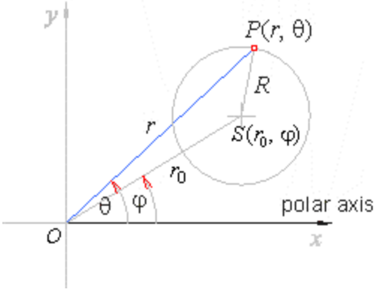


Figure: Polar coordinate system

Initial conditions

For our initial conditions of the least squares algorithm, I set $\theta = \frac{\pi}{4}$ due to all of our tracks begin at the first quadrant. For the radial coordinate I use the **sagitta** approximation as follows

$$R^2 = L^2 + (R - s)^2$$

$$R = \frac{s}{2} + \frac{L^2}{2s}$$

$$s \ll R \rightarrow R \approx \frac{L^2}{2s}$$

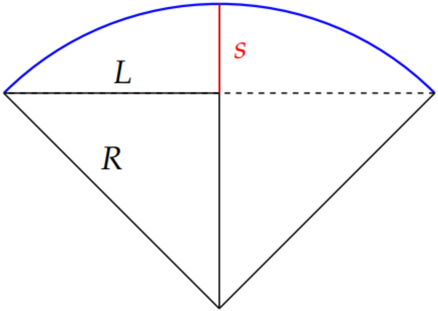
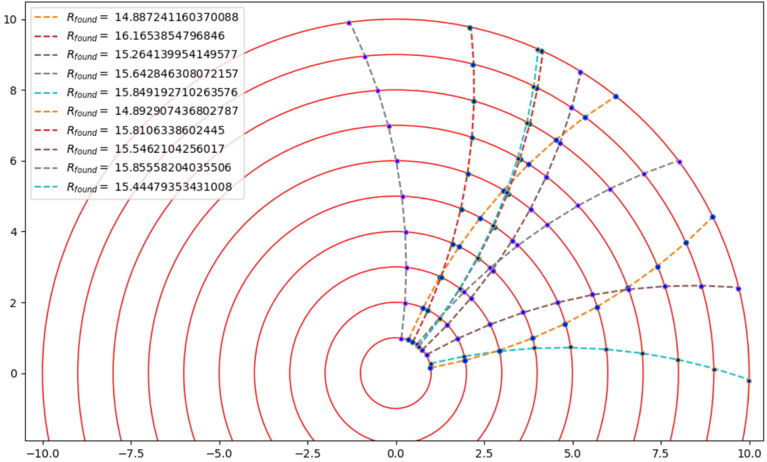


Figure: Aspects of High Energy Physics - Thiago Tomei

Results of the fitting of curves



Next steps

Our interest studying this problem is to better understand how the Track Reconstruction is made at the High Level Trigger. Some of the next steps planned are

- ☐ Implement the dynamics of a charge travelling in a magnetic field region as our propagation model DONE
- ☐ Construct the fitting of a circle which intersects the origin DONE
- ☐ Implement the combinatorial track filtering UNDERWAY