IX MIMO Range Migration Algroritham

9.1 Review

> FMCW, Pulsed, Stepped Freq. } Generalized ✓

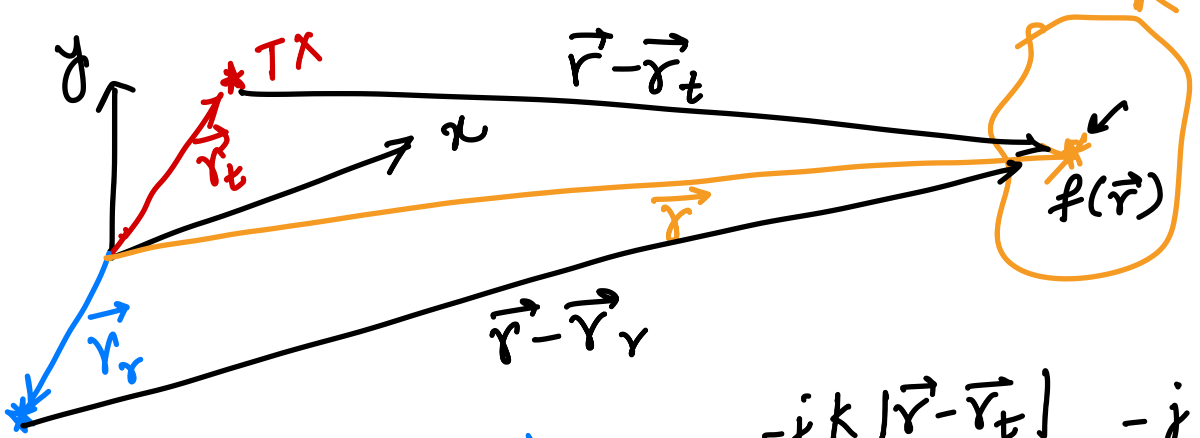
> 3-D SAR reconstruction (B-P, TDC). ✓

> MIMO Radar. ✓ }

> RMA, ω-k, HR... for SAR. ✓ }

> RMA for MIMO radar

9.2 Signal model



$$S_b(\vec{r},\vec{r}_t,\vec{r}_r,k) = \frac{f(\vec{r})\, e^{-jk|\vec{r}-\vec{r}_t|}\, e^{-jk|\vec{r}-\vec{r}_r|}}{16\pi^2|\vec{r}-\vec{r}_t||\vec{r}-\vec{r}_r|}$$

$$\tilde{S}_b(\vec{r}_t,\vec{r}_r,k) = \iiint_{\vec{r}\in R} S_b(\vec{r},\vec{r}_t,\vec{r}_r,k)\,\underbrace{d\vec{r}}_{dx\,dy\,dz}$$

$K = k_t = \frac{w_c+\beta t}{c}$ for FMCW

$K = \frac{w}{c}$ for P & SF radars.

$|\vec{r}-\vec{r}_t| = \sqrt{(x-x_t)^2+(y-y_t)^2+z^2}$

$|\vec{r}-\vec{r}_r| = \sqrt{(x-x_r)^2+(y-y_r)^2+z^2}$

9.3 Range Migration Algorithm for MIMO

$$\hat{S}_b(x_t, y_t, x_r, y_r, k_t) = \iiint_{xyz} \frac{f(x,y,z)\, e^{-jk_t(R_t+R_r)}}{16\pi^2 R_t R_r} dx\,dy\,dz$$

$R_t = |\vec{r} - \vec{r}_t|$

$R_r = |\vec{r} - \vec{r}_r|$

2D FT w.r.t x_t, y_t & 2D FT w.r.t x_r, y_r

$\Rightarrow$ 4D FT w.r.t x_t, y_t, x_r, y_r

$$\tilde{S}_b(k_{x_t}, k_{y_t}, k_{x_r}, k_{y_r}, k_t)$$

$$= \iiint_{xyz} \frac{f(x,y,z)}{16\pi^2} \iint_{x_t y_t} \frac{e^{-jk_t\sqrt{(x-x_t)^2+(y-y_t)^2+z^2}}}{\sqrt{(x-x_t)^2+(y-y_t)^2+z^2}} \times e^{-jk_{x_t}x_t - jk_{y_t}y_t}\, dx_t\, dy_t$$

MOSP

$$\times \iint_{x_r y_r} \frac{e^{-jk_t\sqrt{(x-x_r)^2+(y-y_r)^2+z^2}}}{\sqrt{(x-x_r)^2+(y-y_r)^2+z^2}} e^{-jk_{x_r}x_r - jk_{y_r}y_r}\, dx_r\, dy_r\, dx\,dy\,dz$$

$$= \iiint_{x\,y\,z} \frac{f(x,y,z)}{16\pi^2} \left[\frac{2\pi j}{k_{z_t}} e^{-jzk_{z_t}} e^{-jk_{x_t}x - jk_{y_t}y} \right]$$

$$\left[\frac{2\pi j}{k_{z_r}} e^{-jzk_{z_r} - jk_{x_r}x - jk_{y_r}y} \right]$$

$$\left. \begin{aligned} k_{z_t} &= \sqrt{k_t^2 - k_{x_t}^2 - k_{y_t}^2} \\ k_{z_r} &= \sqrt{k_t^2 - k_{x_r}^2 - k_{y_r}^2} \end{aligned} \right\}$$

$$k_x = k_{x_t} + k_{x_r} \;\&\; k_y = k_{y_t} + k_{y_r}$$

$$k_z = k_{z_t} + k_{z_r}$$

$$= \iiint_{x\,y\,z} \frac{f(x,y,z)}{4 k_{z_t} k_{z_r}} e^{-jk_x x - jk_y y - jk_z z} \, dx\,dy\,dz$$

$$= FT_{3D}\left\{ \frac{f(x,y,z)}{4 k_{z_t} k_{z_r}} \right\} = \tilde{S}_b(k_{x_t}, k_{y_t}, k_{x_r}, k_{y_r}, k_t)$$

$$f(x,y,z) = FT_{3D}^{-1}\left\{ \tilde{S}_b(k_{x_t}, k_{y_t}, k_{x_r}, k_{y_r}, k_t) \times 4 k_{z_t} k_{z_r} \right\}$$

$$\boxed{= FT_{3D}^{-1}\left\{ 4 k_{z_t} k_{z_r} \left\{ FT_{4D} \left\{ S_b(x_t, y_t, x_r, y_r, k_t) \right\}\right\}\right\}}$$

Step ③

3D IFT

Step ②

HPF

+

5D→3D

$$\left\{ \begin{array}{l} \text{Interpolation} \\ k_x = k_{x_t} + k_{x_r} \\ k_y = k_{y_t} + k_{y_r} \\ k_z = k_{z_t} + k_{z_r} \end{array} \right\}$$

Step ①

4D FT