CS 598 WSI, LECTURE 11

Belimating position S Optical flow
SDoppler Shift

 $\label{eq:2.1} \frac{1}{2} \int_{\mathbb{R}^3} \frac{1}{\sqrt{2}} \, \frac{1}{\sqrt{2}} \,$

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 $\label{eq:2.1} \frac{1}{2} \int_{\mathbb{R}^3} \frac{1}{\sqrt{2}} \, \frac{1}{\sqrt{2}} \,$

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Batmobility.

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Position Estimation: RF d istance Angle multipath. $ConS$ γ_{γ_O} Signaline of) Computation. 3 infoastouchin (fingerpoint) -> precise indoors. => need to know Albertian

Position Estimation: IMU) Inertial motion measuriment unit acceleranter Cryossop < magnetameter
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Vision-based Positioning basedpositioningfacamerast.IS $-1DABS$ Cameras T, pocalize \int \sim C 905 > Low light <u>ىن</u> or occlusions cameras usefulformultiph non-line of applications. s robust ecosystem depth is not for detiction cuith a sigle comme) more computation.

[Estimating Velocity] position \rightarrow derivative of position over time velocity can be "easier" $accelaroner \rightarrow$ single integration of acceleration relative motion target velocity = V 0 observed velocity \widehat{c} ⁻ \widehat{v} $\upsilon' \approx v$

outgrain vs. inside out Infrastructure driven Sensoris on the droom. IR (infranel)-based sys^{k} m s is the $\lceil NU \rceil$ on the doone. $\label{eq:2.1} \frac{1}{\sqrt{2\pi}}\left(\frac{1}{\sqrt{2\pi}}\right)^{2} \left(\frac{1}{\sqrt{2\pi}}\right)^{2} \left(\frac{1}{\sqrt{2\pi}}\right)^{2} \left(\frac{1}{\sqrt{2\pi}}\right)^{2} \left(\frac{1}{\sqrt{2\pi}}\right)^{2} \left(\frac{1}{\sqrt{2\pi}}\right)^{2} \left(\frac{1}{\sqrt{2\pi}}\right)^{2} \left(\frac{1}{\sqrt{2\pi}}\right)^{2} \left(\frac{1}{\sqrt{2\pi}}\right)^{2} \left(\frac{1}{\sqrt{2\pi}}\right)^{2$ $\mathcal{L}^{\text{max}}_{\text{max}}$ and $\mathcal{L}^{\text{max}}_{\text{max}}$ and $\mathcal{L}^{\text{max}}_{\text{max}}$ Δ $\mathcal{L}_{\mathcal{A}}$ and $\mathcal{L}_{\mathcal{A}}$ are the set of the set of the set of \mathcal{A} \mathcal{Z} $\mathcal{L}(\mathcal{A})$ and $\mathcal{L}(\mathcal{A})$ $\mathbf{r}^{(i)}$ and $\mathbf{r}^{(i)}$ are the set of the set of the set of $\mathbf{r}^{(i)}$ $\label{eq:2.1} \begin{array}{l} \mathcal{L}_{\mathcal{A}}(\mathcal{A})=\mathcal{L}_{\mathcal{A}}(\mathcal{A})\left(\mathcal{A}\right) \end{array}$ $\mathcal{O}(\mathcal{O}(n^2))$. The contribution of the contribution of $\mathcal{O}(n^2)$ $\label{eq:2.1} \mathcal{L}_{\text{max}}(\mathcal{L}_{\text{max}}) = \mathcal{L}_{\text{max}}(\mathcal{L}_{\text{max}})$ $\mathcal{L}^{\mathcal{L}}(\mathcal{A})$ and $\mathcal{L}^{\mathcal{L}}(\mathcal{A})$ are the set of the following $\mathcal{L}^{\mathcal{L}}(\mathcal{A})$ $\mathcal{L}^{\text{max}}_{\text{max}}$ $\ddot{}$ $\mathcal{L}_{\mathcal{A}}$. The contribution of the $\sim 10^6$ $\mathcal{L}_{\mathcal{A}}$. The contribution of the contribution of the contribution of the contribution of $\ddot{}$ $\ddot{}$ $\ddot{}$ $\hat{\mathcal{E}}$ \mathcal{L}^{max} $\mathcal{O}(\mathcal{O}(n^2))$. The set of th $\label{eq:2.1} \begin{array}{ll} \mathcal{L}_{\text{max}} & \mathcal{L}_{\text{max}} \\ \mathcal{L}_{\text{max}} & \mathcal{L}_{\text{max}} \end{array}$ ~ 10 $\mathcal{L}^{\mathcal{A}}$. The contribution of the contribution of the contribution of the contribution of $\mathcal{L}^{\mathcal{A}}$ ~ 10 $\mathcal{L}^{\mathcal{A}}$ is the contribution of the set of the se $\mathcal{L}(\mathcal{A})$ is a subset of the set of the

Optical Flow \overrightarrow{a} down facing camera $\begin{picture}(120,140) \put(0,0){\line(1,0){155}} \put(15,0){\line(1,0){155}} \put(15,0){\line(1,0){155}} \put(15,0){\line(1,0){155}} \put(15,0){\line(1,0){155}} \put(15,0){\line(1,0){155}} \put(15,0){\line(1,0){155}} \put(15,0){\line(1,0){155}} \put(15,0){\line(1,0){155}} \put(15,0){\line(1,0){155}} \put(15,0){\line(1,0){155$ $\left(\begin{array}{c} \bullet \\ \bullet \\ \bullet \end{array}\right)$ $\begin{picture}(160,170) \put(0,0){\line(1,0){10}} \put(15,0){\line(1,0){10}} \put(15,0){\line$ Challenges dark / bad lighting condition Paris privacy challenges <u>I</u>
I Rador to provide velocity-based on tro,

Doppler Shift RF signals > frequency f. $\begin{CD} \begin{pmatrix} \mathcal{U} & \mathcal{U} \ \mathcal{V} & \mathcal{U} \end{pmatrix} \end{CD}$ $freg = \frac{1}{2} \left(\frac{1}{2} \right)$ C (1 g))
freq of the riflection deppen
o SME = 2 forms velocity > speed
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BatMobility) $\int -v^2$ dopplix shift $\frac{1}{2}$ Je zero $\frac{1}{\sqrt{1-\frac{1$ Surface-parallel doppler shift. dispersion us reflection. FAG: B. D. is the one much smaller 1 than wavelength Jedha

Smooth surface. Me ofthe same order as wavelength rough surface. light is dispersive $W_{t} - F_{t}$ \rightarrow $6 - 12cm$ $m m w$ dave frequencies \rightarrow (Icm few mm floor is dispersive \blacksquare \searrow

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p dupper sny " $\frac{1}{100}$ $anhww$ $\left(\begin{array}{ccc}\n & \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\
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you copher! d pplur $\int h(f(x))dx = \frac{1}{T}$ consider for computed $0.5H₂$ $2s =$

direction of motion Doppler Shift $\frac{1}{\sqrt{2}}$ $\mathbf{0}$ θ -0.5 0.0 0.5 1.0 -1.5 1.0 -1 Ω 1.5 1.5 Angle Angle (a) (left) Motion of the UAV, (center) Simulated doppler-angle plot, (right) Observed doppler-angle plot. Doppler Shift
 $\frac{1}{2}$ o $\frac{1}{2}$ Doppler Shift $\mathbf 1$ $\mathbf 0$ o θ -1 0.5 1.0 1.5 -1.0 0.5 -1.0 -0.5 -1.5 -0.5 0.0 1.0 1.5 Angle (b) (left) Motion of the UAV, (center) Simulated doppler-angle plot, (right) Observed doppler-angle plot. amplitude is frelocity Multipath l limited resolution ground nay no feet

Figure 5: Left. Physical antenna array layouts on single-chip mmWave radar boards. Right. Corresponding numbered virtual antenna array under TDM MIMO.

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Figure 13: Loiter Test. (a) UAV equipped with BatMobility holds its position, but optical flow fails in dark and textureless (a) conditions. (b) Higher update rates support better hovering performance, in spite of higher flow prediction errors shown in (c).

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