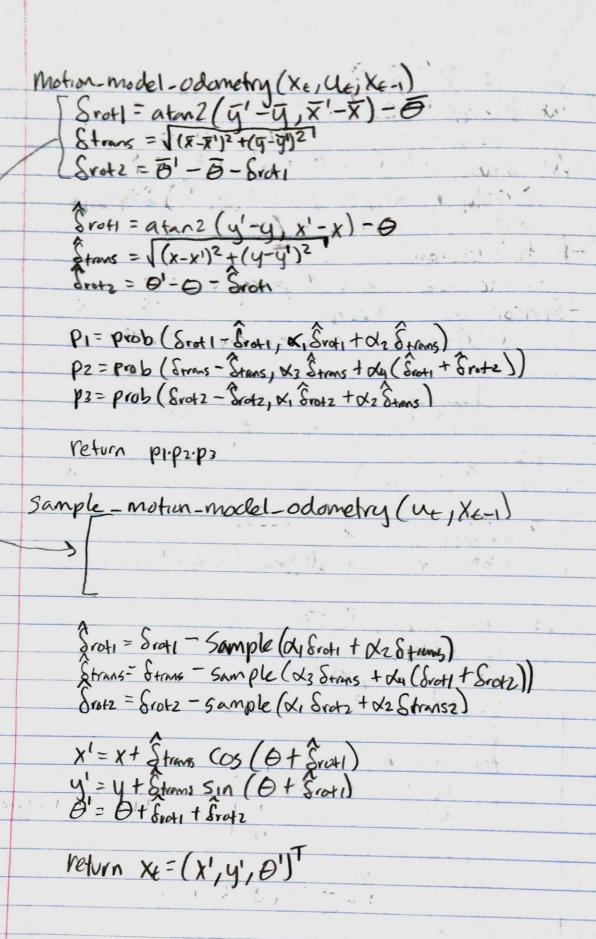
Algorithm, MCL (Xu, u, ze) X = X = Ø for m=1 to Mi

xe = motion_update (ue, xe-1) +> sample xe = p(xelxen, ue)

we = Sensor_update (Ze, xe-1) +> we = p(zelxen)

Xe = Xe & Xe, we > end for for mal to Mi draw Xe from Xe with prohibility & WED Xe = Xe DxC13 end for return XE end Algorithm Kidney Universal X6 = {x6, x6, ..., x60} - randonly add exten particles No = actuation command every iteration 24 = Sensor data X = [x, y, 0] Kist 1) Prediction Phase use motion model to get p(x (Z) Z p(x (Xx-1, un-1) P(Xx-1) 2) Update Phase p(extx) P(xx 12") use measurement model to get P(Xx/2") of p(2m/xx)P(Xx) ex is a single newscronest have P(Ko) XIE IS CULTERY STATE P(Xx/Z) put Zx s set of measurements W= P(X+12+1) a Move then add random noise Notoof has to move of problems! Predict \hat{r} measure \tilde{r} $\hat{f}(\tilde{r}-\hat{r})$

Particle Problems weights go to O -> ne sample -No dowsty - only resumple with large minw -> resumple with variance -Particle Deprovation -> Encrease number of particles - Sensor are to persone -) artificially increase sensor uncertainty f is target distribution q is proposal distribution Wt = Mp(Ze(Xe) resampling -> Never Wen stopped (suspond measurements too) LOW- VLI_Scompling (XE, We) r = rand (U, M-1) i=1 tor m=1:M u=r+(m+) M while U>C C+= W(end while odd Xt to X end for return X



Measurement Errors 1) Small neasurement noise - gaussian 2) errors from unexpected Objects - experiential 3) errors du to ladures to detact objects - uniform (at max) 4) random noise - uniform over entre range 1) Phit = { n N (ZE; ZE, Onit) if 0 = ZE = Z max N(2+; 2+, 02) = 1 (210 0 + exp (-1, (21 - 2+)2) n=(SoN 12k) 2) Pshort = {m \short exp (-\short \frac{1}{2}) if 0 = \frac{1}{2} = \fr 7= (1- exp(-1short 2 =)) 4) Prand = { = max if 0 = Zx < 2 max 0 else P(ZE/XE, M) X Short Pshort Print Print Print) Knift & Short + Xmext Xrand = 1 beam_range_finder_model (Zeike, M): 9=1 For K=1 to K get 24 Using ray Casting get P(Z+ (X+,m); q = P

return q

learn_intrinsk_parameters (Z, X, m) repeat until some convergence criterion for all zinz do 7= (Phit + Pshot + Proax + Frand) calc 2* Ci, hit = 9 Phit lixand = MPrand Zhit = 121 - Zi ei hit Zrand = 121 = Eierard Onit = V Elihit (2i-2*)2 Ashort = Zeishort Zi Noturn D = { Rhit, Zshort, Zmax, Zmand, Onit, Asharts monitor p (serior neasurments) & M & We (warmy overtime steps Augmented_MCL (X+1, U+1Z+1M) Static Wslow, West; TE=X== P for m=1:M XEM = Sumple_motion_model (ue, XE-1) Wt = measurement-model (Ze, XEM) M) Warg = Warg + M WEM Wslow += Xslow (Warg-Wslow) Wfast t= offast (Wavg - Wfag) for m=1:M with Proposition = max (0, 1- what) add random pose to Xe else draw 16 {1, ..., N& w/ prob & WE add X to X return Xt