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# Unscented Kalman Filters

REVIEW

CODE REVIEW 11

HISTORY

▼ src/ukf.cpp 11

```
1 #include "ukf.h"
2 #include "Eigen/Dense"
3 #include <iostream>
4
5 #define EPS 0.001
6
7 using namespace std;
8 using Eigen::MatrixXd;
9 using Eigen::VectorXd;
10 using std::vector;
11
12 /**
13  * Initializes Unscented Kalman filter
14  * This is scaffolding, do not modify
15  */
16 UKF::UKF() {
17     // if this is false, laser measurements will be ignored (except during init)
18     use_laser_ = true;
19
20     // if this is false, radar measurements will be ignored (except during init)
21     use_radar_ = true;
22
23     // initial state vector
24     x_ = VectorXd(5);
25
26     // initial covariance matrix
27     P_ = MatrixXd(5, 5);
28     P_ << 1, 0, 0, 0, 0,
29     0, 1, 0, 0, 0,
30     0, 0, 1, 0, 0,
31     0, 0, 0, 1, 0,
32     0, 0, 0, 0, 1;
```

AWESOME

Initializing `P_` with an identity matrix is a good way to go!

```

33
34 // Process noise standard deviation longitudinal acceleration in m/s^2
35 std_a_ = 1.5;
36
37 // Process noise standard deviation yaw acceleration in rad/s^2
38 std_yawdd_ = 0.5;

```



AWESOME

Good choice of `std_a_` and `std_yawdd_` values.

```

39
40 //DO NOT MODIFY measurement noise values below these are provided by the sensor manufa
41 // Laser measurement noise standard deviation position1 in m
42 std_laspx_ = 0.15;
43
44 // Laser measurement noise standard deviation position2 in m
45 std_laspy_ = 0.15;
46
47 // Radar measurement noise standard deviation radius in m
48 std_radr_ = 0.3;
49
50 // Radar measurement noise standard deviation angle in rad
51 std_radphi_ = 0.03;
52
53 // Radar measurement noise standard deviation radius change in m/s
54 std_radrd_ = 0.3;
55 //DO NOT MODIFY measurement noise values above these are provided by the sensor manufa
56
57 /**
58 TODO:
59
60 Complete the initialization. See ukf.h for other member properties.
61
62 Hint: one or more values initialized above might be wildly off...
63 */
64 // intialize set to False. Set to true after 1st measurement
65 is_initialized_ = false;
66
67 // time when the state is true, in us
68 time_us_ = 0;
69
70 // state dimension
71 n_x_ = 5;
72
73 // aummented state dimension
74 n_aug_ = 7;
75
76 /*** Sigma points dimension
77 n_sig_ = 2 * n_aug_ + 1;
78
79 // Sigma point spreading parameter
80 lambda_ = 3 - n_x_;
81
82 // Initialize weights.
83 weights_ = VectorXd(n_sig_);
84 weights_.fill(0.5 / (n_aug_ + lambda_));
85 weights_(0) = lambda_ / (lambda_ + n_aug_);

```

## AWESOME

Great to see you set the weights early on, in the constructor itself.

```

86
87     //Predicted sigma points matrix
88     Xsig_pred_ = MatrixXd(n_x_, n_sig_);
89
90     // the current NIS for radar
91     NIS_radar_ = 0.0;
92
93     // the current NIS for laser
94     NIS_lidar_ = 0.0;
95
96     // Initialize measure noise covariance
97     R_radar_ = MatrixXd(3,3);
98     R_lidar_ = MatrixXd(2,2);
99     R_radar_ << std_radr_*std_radr_,0,0,
100                0,std_radphi_*std_radphi_,0,
101                0,0, std_radrd_*std_radrd_;
102     R_lidar_ << std_laspx_*std_laspx_,0,
103                0, std_laspy_*std_laspy_;

```

## SUGGESTION

Great to see you prepared these matrices in the constructor itself.

```

104
105
106 }
107
108 UKF::~UKF() {}
109
110 /**
111  * @param {MeasurementPackage} meas_package The latest measurement data of
112  * either radar or laser.
113  */
114 void UKF::ProcessMeasurement(MeasurementPackage meas_package) {
115     /**
116      TODO:
117
118      Complete this function! Make sure you switch between lidar and radar
119      measurements.
120      */
121     if ( !is_initialized_ ) {
122         if (meas_package.sensor_type_ == MeasurementPackage::RADAR) {
123             double rho = meas_package.raw_measurements_[0]; // range
124             double phi = meas_package.raw_measurements_[1]; // bearing
125             double rho_dot = meas_package.raw_measurements_[2]; // velocity of rho
126             double x = rho * cos(phi);
127             double y = rho * sin(phi);
128             double vx = rho_dot * cos(phi);
129             double vy = rho_dot * sin(phi);
130             double v = sqrt(vx * vx + vy * vy);

```

## SUGGESTION

Here `v` evaluates to `rho_dot` itself due to the trigonometry identity  $\sin^2(\theta) + \cos^2(\theta) = 1$

```

131         x_ << x, y, v, 0, 0;

```

```

132         } else {
133             x_ << meas_package.raw_measurements_[0], meas_package.raw_measurements_[1],
134         }
135
136         // Saving first timestamp in seconds
137         time_us_ = meas_package.timestamp_ ;
138         // done initializing, no need to predict or update
139         is_initialized_ = true;
140         return;
141     }
142
143     // Calculate dt
144     double dt = (meas_package.timestamp_ - time_us_) / 1000000.0;
145     time_us_ = meas_package.timestamp_;
146     // Prediction step
147     //cout<<"DEBUG: Prediction Starts" << endl;
148
149     Prediction(dt);
150     //cout<<"DEBUG: Prediction Ends" << endl;
151
152
153     if (meas_package.sensor_type_ == MeasurementPackage::RADAR && use_radar_) {
154         UpdateRadar(meas_package);
155     }
156     if (meas_package.sensor_type_ == MeasurementPackage::LASER && use_laser_) {
157         UpdateLidar(meas_package);
158     }
159 }
160 /**
161  * Predicts sigma points, the state, and the state covariance matrix.
162  * @param {double} delta_t the change in time (in seconds) between the last
163  * measurement and this one.
164  */
165 void UKF::Prediction(double delta_t) {
166     /**
167      * TODO:
168
169      * Complete this function! Estimate the object's location. Modify the state
170      * vector, x_. Predict sigma points, the state, and the state covariance matrix.
171      */
172
173     // 1. Generate sigma points.
174     //create augmented mean vector
175     VectorXd x_aug = VectorXd(n_aug_);
176     x_aug.head(5) = x_;
177     x_aug(5) = 0;
178     x_aug(6) = 0;
179
180     //create augmented state covariance
181     MatrixXd P_aug = MatrixXd(n_aug_, n_aug_);
182     P_aug.fill(0.0);
183     P_aug.topLeftCorner(n_x_, n_x_) = P_;
184     P_aug(5,5) = std_a_*std_a_;
185     P_aug(6,6) = std_yawdd_*std_yawdd_;

```

#### SUGGESTION

You can prepare this Q matrix in the constructor itself because it does not change over iterations.

```

186
187     // Creating sigma points.
188     MatrixXd Xsig_aug = GenerateSigmaPoints(x_aug, P_aug, lambda_, n_sig_);
189
190     // 2. Predict Sigma Points.

```

```

191     Xsig_pred_ = PredictSigmaPoints(Xsig_aug, delta_t, n_x_, n_sig_, std_a_, std_yawdd_)
192
193     // 3. Predict Mean and Covariance
194     //predicted state mean
195     x_ = Xsig_pred_ * weights_;
196
197     cout << " DEBUG: Predict x_ = " << x_ << endl;
198
199     //predicted state covariance matrix
200     P_.fill(0.0);
201     for (int i = 0; i < n_sig_; i++) { //iterate over sigma points
202
203         // state difference
204         VectorXd x_diff = Xsig_pred_.col(i) - x_;
205         //angle normalization
206         x_diff = NormalizeAngle(x_diff, 3);
207
208         P_ = P_ + weights_(i) * x_diff * x_diff.transpose() ;
209     }
210
211 }

```



### AWESOME

I liked how you divided the **Prediction** part into three subparts with two sub-functions. This makes it easier to go through and also easy to maintain.

```

212
213
214 /**
215  * Updates the state and the state covariance matrix using a laser measurement.
216  * @param {MeasurementPackage} meas_package
217  */
218 void UKF::UpdateLidar(MeasurementPackage meas_package) {

```



### SUGGESTION

You can update lidar using the linear method as you did in the EKF project. Because lidar measurement model is a linear model, it saves computational burden.

```

219  /**
220  TODO:
221
222  Complete this function! Use lidar data to update the belief about the object's
223  position. Modify the state vector, x_, and covariance, P_.
224
225  You'll also need to calculate the lidar NIS.
226  */
227
228     int n_z = 2;
229
230     //Step 1: Predict measurement mean and covariance
231     //create example matrix with sigma points in measurement space
232
233     MatrixXd Zsig = Xsig_pred_.block(0,0,n_z,n_sig_);
234
235     //Create example vector for mean predicted measurement
236     VectorXd z_pred = VectorXd(n_z);
237     z_pred.fill(0.0);
238     for (int i=0; i < n_sig_; i++) {
239         z_pred = z_pred + weights_(i) * Zsig.col(i);

```

```

240     }
241
242     //Create example vector for covariance predicted measurement
243     MatrixXd S = MatrixXd(n_z,n_z);
244     S.fill(0.0);
245     for (int i = 0; i < n_sig_; i++) {
246         //residual
247         VectorXd z_diff = Zsig.col(i) - z_pred;
248         S = S + weights_(i) * z_diff * z_diff.transpose();
249     }
250
251     //add measurement noise covariance matrix
252     S = S + R_lidar_;
253
254     //Step 2: Update State mean and Covariance
255
256     // Incoming lidar measurement
257     VectorXd z = meas_package.raw_measurements_;
258
259     //Cross-correlation between sigma opints in state space and measurement space
260     MatrixXd Tc = MatrixXd(n_x_,n_z);
261     Tc.fill(0.0);
262     for (int i = 0; i < n_sig_; i++) { //2n+1 sigma points
263
264         //residual
265         VectorXd z_diff = Zsig.col(i) - z_pred;
266
267         // state difference
268         VectorXd x_diff = Xsig_pred_.col(i) - x_;
269
270         Tc = Tc + weights_(i) * x_diff * z_diff.transpose();
271     }
272
273     //Kalman gain K;
274     MatrixXd K = Tc * S.inverse();
275
276     //residual
277     VectorXd z_diff = z - z_pred;
278
279     //update state mean and covariance
280     x_ = x_ + K * z_diff;
281     P_ = P_ - K*S*K.transpose();
282     cout << "DEBUG: UpdateLidar x_ = " << x_ <<endl;
283
284     //NIS Lidar Update
285     NIS_lidar_ = z_diff.transpose() * S.inverse() * z_diff;
286 }
287
288 /**
289  * Updates the state and the state covariance matrix using a radar measurement.
290  * @param {MeasurementPackage} meas_package
291  */
292 void UKF::UpdateRadar(MeasurementPackage meas_package) {
293     /**
294     TODO:
295
296     Complete this function! Use radar data to update the belief about the object's
297     position. Modify the state vector, x_, and covariance, P_.
298
299     You'll also need to calculate the radar NIS.
300     */
301
302     //Radar dimension
303     int n_z = 3;
304
305     // Step 1: Predict measurement mean and covariance

```

```

306
307 // create example matrix with sigma points in measurement space
308 MatrixXd Zsig = MatrixXd(n_z,n_sig_);
309
310 //transform sigma points into measurement space
311
312 for (int i = 0; i < n_sig_ ; i++) { //2n+1 sigma points
313
314     // extract values for better readability
315     double p_x = Xsig_pred_(0,i);
316     double p_y = Xsig_pred_(1,i);
317     double v   = Xsig_pred_(2,i);
318     double yaw = Xsig_pred_(3,i);
319
320     double v1 = cos(yaw)*v;
321     double v2 = sin(yaw)*v;
322
323     // measurement model
324     Zsig(0,i) = sqrt(p_x*p_x + p_y*p_y); //r
325     Zsig(1,i) = atan2(p_y,p_x); //phi
326     Zsig(2,i) = (p_x*v1 + p_y*v2) / sqrt(p_x*p_x + p_y*p_y); //r_dot
327 }
328
329 //Create example vector for mean predicted measurement
330 VectorXd z_pred = VectorXd(n_z);
331 z_pred.fill(0.0);
332 for (int i=0; i < n_sig_ ; i++) {
333     z_pred = z_pred + weights_(i) * Zsig.col(i);
334 }
335
336 //Create example vector for covariance predicted measurement
337 MatrixXd S = MatrixXd(n_z,n_z);
338 S.fill(0.0);
339 for (int i = 0; i < n_sig_ ; i++) { //2n+1 sigma points
340     //residual
341     VectorXd z_diff = Zsig.col(i) - z_pred;
342
343     //angle normalization
344     z_diff = NormalizeAngle(z_diff, 1);
345
346     S = S + weights_(i) * z_diff * z_diff.transpose();
347 }
348
349 //add measurement noise covariance matrix
350 S = S + R_radar_;
351
352 // Step 2: Update State mean and Covariance
353
354 VectorXd z = meas_package.raw_measurements_;
355
356 //Cross-correlation between sigma opints in state space and measurement space
357 MatrixXd Tc = MatrixXd(n_x,n_z);
358 Tc.fill(0.0);
359
360 for (int i = 0; i < n_sig_ ; i++) { //2n+1 sigma points
361
362     //residual
363     VectorXd z_diff = Zsig.col(i) - z_pred;
364
365     //normalize angle
366     z_diff = NormalizeAngle(z_diff, 1);
367
368     // state difference
369     VectorXd x_diff = Xsig_pred_.col(i) - x_;
370     //normalize angle
371     NormalizeAngle(x_diff, 3);

```

```

372
373     Tc = Tc + weights_(i) * x_diff * z_diff.transpose();
374 }
375
376 //Kalman gain K;
377 MatrixXd K = Tc * S.inverse();
378
379 //residual
380 VectorXd z_diff = z - z_pred;
381 //angle normalization
382 NormalizeAngle(z_diff, 1);
383
384 //update state mean and covariance
385 x_ = x_ + K * z_diff;
386 P_ = P_ - K*S*K.transpose();
387 cout <<"DEBUG: Update Radar: x_ = " << x_ << endl;
388
389 //NIS Radar Update
390 NIS_radar_ = z_diff.transpose() * S.inverse() * z_diff;
391
392
393 }
394
395 /*****
396  * Generate Sigma Points
397  *****/
398 MatrixXd UKF::GenerateSigmaPoints(VectorXd x, MatrixXd P, double lambda, int n_sig)
399 {
400     int n = x.size();
401     //create sigma point matrix
402     MatrixXd Xsig = MatrixXd( n, n_sig );
403
404     //calculate square root of P
405     MatrixXd A = P.llt().matrixL();
406
407     Xsig.col(0) = x;
408
409     double lambda_plus_n_x_sqrt = sqrt(lambda + n);
410     for (int i = 0; i < n; i++){
411         Xsig.col( i + 1 ) = x + lambda_plus_n_x_sqrt * A.col(i);
412         Xsig.col( i + 1 + n ) = x - lambda_plus_n_x_sqrt * A.col(i);
413     }
414     return Xsig;
415 }
416
417 /*****
418  * Predict Sigma Points with process noise
419  *****/
420 MatrixXd UKF::PredictSigmaPoints(MatrixXd Xsig, double delta_t, int n_x, int n_sig, doub
421 {
422     MatrixXd Xsig_pred = MatrixXd(n_x,n_sig);
423
424     for (int i = 0; i< n_sig; i++)
425     {
426         double p_x = Xsig(0,i);
427         double p_y = Xsig(1,i);
428         double v = Xsig(2,i);
429         double yaw = Xsig(3,i);
430         double yawd = Xsig(4,i);
431         double nu_a = Xsig(5,i);
432         double nu_yawdd = Xsig(6,i);

```

▲  
SUGGESTION



It would be good to declare variables that will not or should not change in the current scope as `const` throughout your code to help to optimize the code while compilation.

```

433
434     //predicted state values
435     double px_p, py_p;
436
437     //avoid division by zero
438     if (fabs(yawd) > EPS) {
439         px_p = p_x + v/yawd * ( sin (yaw + yawd*delta_t) - sin(yaw));
440         py_p = p_y + v/yawd * ( cos(yaw) - cos(yaw+yawd*delta_t) );
441     }
442     else {
443         px_p = p_x + v*delta_t*cos(yaw);
444         py_p = p_y + v*delta_t*sin(yaw);
445     }
446
447     double v_p = v;
448     double yaw_p = yaw + yawd*delta_t;
449     double yawd_p = yawd;
450
451     //add noise
452     px_p = px_p + 0.5*nu_a*delta_t*delta_t * cos(yaw);
453     py_p = py_p + 0.5*nu_a*delta_t*delta_t * sin(yaw);
454     v_p = v_p + nu_a*delta_t;
455
456     yaw_p = yaw_p + 0.5*nu_yawdd*delta_t*delta_t;
457     yawd_p = yawd_p + nu_yawdd*delta_t;
458
459     //write predicted sigma points into Sigma Matrix
460     Xsig_pred(0,i) = px_p;
461     Xsig_pred(1,i) = py_p;
462     Xsig_pred(2,i) = v_p;
463     Xsig_pred(3,i) = yaw_p;
464     Xsig_pred(4,i) = yawd_p;
465 }
466
467 return Xsig_pred;
468 }
469
470 VectorXd UKF::NormalizeAngle(VectorXd vector, int angleIdx)
471 {
472     while (vector(angleIdx) > M_PI) vector(angleIdx)-= 2*M_PI;
473     while (vector(angleIdx) < -M_PI) vector(angleIdx)+= 2*M_PI;
474     return vector;

```



AWESOME

Great to see that you made a function for normalizing the angles.

475 }



AWESOME

Overall I liked how your comments are well-structured throughout the code. This makes it easier to go through the code.

476

- ▶ src/tools.h
- ▶ src/tools.cpp
- ▶ src/measurement\_package.h
- ▶ src/main.cpp
- ▶ src/Eigen/src/plugins/MatrixCwiseUnaryOps.h
- ▶ src/Eigen/src/plugins/MatrixCwiseBinaryOps.h
- ▶ src/Eigen/src/plugins/CommonCwiseUnaryOps.h
- ▶ src/Eigen/src/plugins/CommonCwiseBinaryOps.h
- ▶ src/Eigen/src/Geometry/Homogeneous.h
- ▶ src/Eigen/src/Geometry/EulerAngles.h
- ▶ src/Eigen/src/Geometry/CMakeLists.txt
- ▶ src/Eigen/src/Geometry/AngleAxis.h
- ▶ src/Eigen/src/Geometry/AlignedBox.h
- ▶ src/Eigen/src/Eigenvalues/Tridiagonalization.h
- ▶ src/Eigen/src/Eigenvalues/RealSchur\_MKL.h
- ▶ src/Eigen/src/Eigenvalues/RealSchur.h
- ▶ src/Eigen/src/Eigenvalues/RealQZ.h
- ▶ src/Eigen/src/Eigenvalues/HessenbergDecomposition.h
- ▶ src/Eigen/src/Eigenvalues/ComplexSchur\_MKL.h
- ▶ src/Eigen/src/Eigenvalues/ComplexSchur.h
- ▶ src/Eigen/src/Eigenvalues/CMakeLists.txt
- ▶ src/Eigen/src/Eigen2Support/VectorBlock.h

- ▶ `src/Eigen/src/Eigen2Support/TriangularSolver.h`
- ▶ `src/Eigen/src/Eigen2Support/SVD.h`
- ▶ `src/Eigen/src/Eigen2Support/QR.h`
- ▶ `src/Eigen/src/Eigen2Support/Minor.h`
- ▶ `src/Eigen/src/Eigen2Support/Meta.h`
- ▶ `src/Eigen/src/Eigen2Support/Memory.h`
- ▶ `src/Eigen/src/Eigen2Support/MathFunctions.h`
- ▶ `src/Eigen/src/Eigen2Support/Macros.h`
- ▶ `src/Eigen/src/Eigen2Support/LeastSquares.h`
- ▶ `src/Eigen/src/Eigen2Support/Lazy.h`
- ▶ `src/Eigen/src/Eigen2Support/LU.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/Translation.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/Transform.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/Scaling.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/RotationBase.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/Rotation2D.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/Quaternion.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/ParametrizedLine.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/Hyperplane.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/CMakeLists.txt`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/AngleAxis.h`
- ▶ `src/Eigen/src/Eigen2Support/Geometry/All.h`

- ▶ src/Eigen/src/Eigen2Support/Geometry/AlignedBox.h
- ▶ src/Eigen/src/Eigen2Support/CwiseOperators.h
- ▶ src/Eigen/src/Eigen2Support/Cwise.h
- ▶ src/Eigen/src/Eigen2Support/CMakeLists.txt
- ▶ src/Eigen/src/Eigen2Support/Block.h
- ▶ src/Eigen/src/Core/util/XprHelper.h
- ▶ src/Eigen/src/Core/util/StaticAssert.h
- ▶ src/Eigen/src/Core/util/ReenableStupidWarnings.h
- ▶ src/Eigen/src/Core/util/NonMPL2.h
- ▶ src/Eigen/src/Core/util/Meta.h
- ▶ src/Eigen/src/Core/util/Memory.h
- ▶ src/Eigen/src/Core/util/Macros.h
- ▶ src/Eigen/src/Core/util/MKL\_support.h
- ▶ src/Eigen/src/Core/util/ForwardDeclarations.h
- ▶ src/Eigen/src/Core/util/DisableStupidWarnings.h
- ▶ src/Eigen/src/Core/util/Constants.h
- ▶ src/Eigen/src/Core/util/CMakeLists.txt
- ▶ src/Eigen/src/Core/util/BlasUtil.h
- ▶ src/Eigen/src/Core/products/TriangularSolverVector.h
- ▶ src/Eigen/src/Core/products/TriangularSolverMatrix\_MKL.h
- ▶ src/Eigen/src/Core/products/TriangularSolverMatrix.h
- ▶ src/Eigen/src/Core/products/TriangularMatrixVector\_MKL.h

- ▶ `src/Eigen/src/Core/products/TriangularMatrixVector.h`
- ▶ `src/Eigen/src/Core/products/TriangularMatrixMatrix_MKL.h`
- ▶ `src/Eigen/src/Core/products/TriangularMatrixMatrix.h`
- ▶ `src/Eigen/src/Core/products/SelfadjointRank2Update.h`
- ▶ `src/Eigen/src/Core/products/SelfadjointProduct.h`
- ▶ `src/Eigen/src/Core/products/SelfadjointMatrixVector_MKL.h`
- ▶ `src/Eigen/src/Core/products/SelfadjointMatrixVector.h`
- ▶ `src/Eigen/src/Core/products/SelfadjointMatrixMatrix_MKL.h`
- ▶ `src/Eigen/src/Core/products/SelfadjointMatrixMatrix.h`
- ▶ `src/Eigen/src/Core/products/Parallelizer.h`
- ▶ `src/Eigen/src/Core/products/GeneralMatrixVector_MKL.h`
- ▶ `src/Eigen/src/Core/products/GeneralMatrixVector.h`
- ▶ `src/Eigen/src/Core/products/GeneralMatrixMatrix_MKL.h`
- ▶ `src/Eigen/src/Core/products/GeneralMatrixMatrixTriangular_MKL.h`
- ▶ `src/Eigen/src/Core/products/GeneralMatrixMatrixTriangular.h`
- ▶ `src/Eigen/src/Core/products/GeneralMatrixMatrix.h`
- ▶ `src/Eigen/src/Core/products/GeneralBlockPanelKernel.h`
- ▶ `src/Eigen/src/Core/products/CoeffBasedProduct.h`
- ▶ `src/Eigen/src/Core/products/CMakeLists.txt`
- ▶ `src/Eigen/src/Core/arch/SSE/PacketMath.h`
- ▶ `src/Eigen/src/Core/arch/SSE/MathFunctions.h`
- ▶ `src/Eigen/src/Core/arch/SSE/Complex.h`

- ▶ `src/Eigen/src/Core/arch/SSE/CMakeLists.txt`
- ▶ `src/Eigen/src/Core/arch/NEON/PacketMath.h`
- ▶ `src/Eigen/src/Core/arch/NEON/Complex.h`
- ▶ `src/Eigen/src/Core/arch/NEON/CMakeLists.txt`
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- ▶ ide\_profiles/xcode/CMakeFiles/3.11.1/CompilerIdC/CompilerIdC.build/Debug/CompilerIdC.build/CompilerIdC-generated-files.hmap
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- ▶ ide\_profiles/xcode/CMakeFiles/3.11.1/CompilerIdC/CompilerIdC.build/Debug/CompilerIdC.build/CompilerIdC-all-non-framework-target-headers.hmap
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- ▶ ide\_profiles/xcode/CMakeFiles/3.11.1/CompilerIdC/CMakeCCompilerId.c
- ▶ ide\_profiles/xcode/CMakeFiles/3.11.1/CMakeSystem.cmake
- ▶ ide\_profiles/xcode/CMakeFiles/3.11.1/CMakeDetermineCompilerABI\_CXX.bin
- ▶ ide\_profiles/xcode/CMakeFiles/3.11.1/CMakeDetermineCompilerABI\_C.bin
- ▶ ide\_profiles/xcode/CMakeFiles/3.11.1/CMakeCXXCompiler.cmake
- ▶ ide\_profiles/xcode/CMakeFiles/3.11.1/CMakeCCompiler.cmake
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