

**CS825-001, Spring/Summer 2020**  
**Assignment 4- Part 2**  
**Submitted to Dr. Xue Dong Yang**  
**By**  
**Adarsh Koppa Manjunath**  
**200397257**

**Question 2-**

**A) divide the spectrum into a set of rings**

**Set of Rings Method - Computation Performed with the input car image**

```
(base) C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2>python "set of rings.py" "C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\input images\car.raw" 256 256 "C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\output"
here

original image
[[195 196 180 ... 173 183 178]
 [180 190 191 ... 180 185 174]
 [173 178 178 ... 187 186 159]
 ...
 [ 35 33 36 ... 89 85 81]
 [ 35 38 42 ... 88 85 78]
 [ 35 38 38 ... 88 90 82]]

complex image-
[[ 125.+0.j -126.+0.j 189.+0.j ... -173.+0.j 183.+0.j -178.+0.j]
 [-180.+0.j 198.+0.j -191.+0.j ... 180.+0.j -185.+0.j 174.+0.j]
 [ 173.+0.j -178.+0.j 178.+0.j ... -187.+0.j 186.+0.j -159.+0.j]
 ...
 [-35.+0.j 33.+0.j -36.+0.j ... 89.+0.j -85.+0.j 81.+0.j]
 [ 35.+0.j -38.+0.j 42.+0.j ... -88.+0.j 85.+0.j -78.+0.j]
 [-35.+0.j 38.+0.j -38.+0.j ... 88.+0.j -90.+0.j 82.+0.j]]

dft-
[[ 6.34765625e-03+0.j 4.18463518e-03+0.00317044j
 8.3060653e-03+0.00760937j ... 1.61494179e-03+0.00349228j
 8.3060653e-03+0.00760937j 4.18463518e-03+0.00317044j]
 [ 3.49852299e-03+0.00165883j -4.17999456e-03+0.0011386j
 1.54780424e-03+0.00057368j ... 3.08809177e-03+0.00183597j
 -8.31989481e-04+0.0031885j -6.07854557e-04+0.00038355j]
 [ 5.34632177e-03+0.00476163j -2.95489490e-03+0.00374931j
 4.07682772e-03+0.00418956j ... -4.67085732e-06+0.00578146j
 3.65569746e-03+0.00198576j 4.64127131e-04-0.00294768j]
 ...
 [ 3.35323809e-03+0.00134421j -7.06318365e-04+0.0020256j
 3.18572887e-03+0.00431925j ... -5.95257542e-03+0.00720007j
 4.63999293e-03+0.00089872j 4.20562183e-03+0.00579222j]
 [ 5.34632177e-03+0.00476163j 4.64127131e-04+0.00294768j
 3.65569746e-03+0.00198576j ... -3.48943018e-03+0.00415708j
 4.07682772e-03+0.00418956j -2.95489490e-03+0.00374931j]
 [ 3.49852299e-03+0.00165883j -6.07854557e-04+0.00038355j
 -8.31989481e-04+0.0031885j ... -9.85476165e-04+0.00688212j
 1.54780424e-03+0.00057368j -4.17999456e-03+0.0011386j ]]

dimension of the vector- 328
[52.469573974699575, 69.83460218872119, 83.82085218917105, 70.82574437258544, 34.742234188710825, 77.39286375197487, 56.83542764773883, 52.81267427078526, 62.833952579758654, 53.289786587674294, 51.63153327731127, 47.124957685444784, 57.822857327898984, 52.524951
64753787, 44.83217728894978, 43.734283949838854, 39.71426822872124, 49.15155128708291, 47.953675920238744, 41.31516156185698, 35.573948621208064, 40.61741548119194, 38.469277847942536, 37.68628620849149, 40.08832949977212, 41.4559892416395, 40.879636198318445, 35
.70352552686985, 34.458274154804154, 37.763316348851057, 32.02757481651116, 29.34343694834999, 32.842992857985704, 30.965128161322136, 33.24465558584552, 29.7846241065261, 35.52724542983474, 33.74314771295661, 33.34264156584384, 35.30765736899596, 31.4165911898387
34, 34.64823237338109, 31.85924041111705, 35.59843388731317, 32.777085646115684, 30.77785580800428, 28.90761868887787, 30.63554741189783, 30.8827942225074, 31.2700115266155, 31.789504851308729, 32.16530955518889, 27.726371888895402, 28.25348763263184, 28
.17935782655996, 29.55516818497086, 23.53158591311965, 27.865387995529215, 24.34580181894279, 25.34339873330367, 24.21474668643624, 24.9664811199178, 24.46530777588413, 24.542944748321393, 23.728581885429918, 26.10466596959826, 23.773284136981967, 25.53671416
12445, 25.777813821467674, 22.77089849499243, 22.595736616816188, 21.566725271411947, 21.94418235964828, 22.411578608797833, 22.57234840816762, 23.081812968532287, 21.91573194128895, 21.948590217873613, 20.49861320892742, 18.673548618561943, 20.289784589175265
, 18.2428331321111, 19.406408173281185, 17.319758393940289, 19.1244458270804, 20.2022367878154, 18.24888931415784, 19.461698840930717, 17.44618882223884, 20.17259964640578, 17.83081525713152, 19.381183773980876, 17.8161166818972, 17.45971462656687, 17.951025
4227451, 17.969696969636299, 17.89564143190604, 18.408985728708174, 18.061126121882756, 18.464387305744363, 16.32211829988466, 18.03672530387826, 16.8169368489788308, 15.18568256747818, 16.138045527346921, 15.330815089914275, 16.5255738655389, 15.8645389120984
62, 15.28397838791782, 14.87758477967836, 14.450456518734967, 16.185535645620867, 14.5828833726988, 15.752932816677343, 14.435586775151197, 14.822489297694562, 14.44882484176835, 14.987311748594877, 14.738852375840278, 15.220885194255924, 14.205837939829614, 1
4.983576183722583, 15.158308649596664, 15.40575782806253, 13.805982819174613, 14.408894811721991, 13.23091233752094, 156.01156430914162]
```

**Fig 1- Computation Performed with the input car image using Set of Rings**

## Set of Rings Method - Frequency Histogram using set of rings for car image

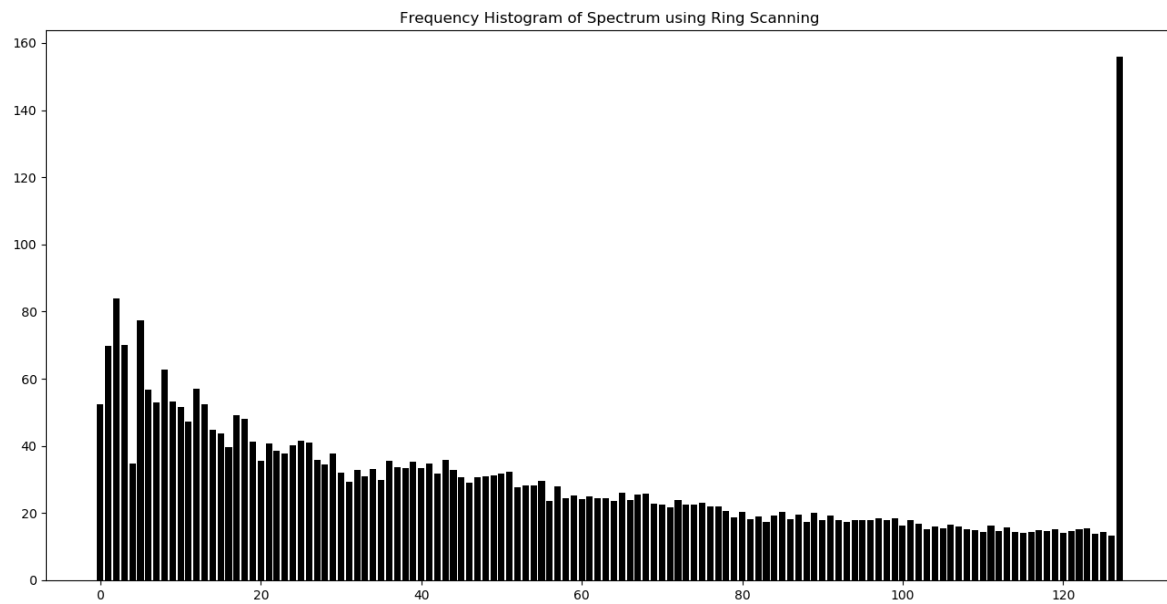


Fig 2- Frequency Histogram using set of rings for car image

## Set of Rings Method - Computation Performed with the input square 256 image

```
(base) C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\python "set of rings.py" "C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\input images\square256.raw" 256 256 "C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\output"
here

original image
[[0 0 ... 0 0 0]
 [0 0 ... 0 0 0]
 [0 0 ... 0 0 0]
 ...
 [0 0 ... 0 0 0]
 [0 0 ... 0 0 0]
 [0 0 ... 0 0 0]]

complex image
[[0.+0.j -0.+0.j ... -0.+0.j 0.+0.j -0.+0.j]
 [-0.+0.j 0.+0.j ... 0.+0.j -0.+0.j 0.+0.j]
 [0.+0.j -0.+0.j ... -0.+0.j 0.+0.j -0.+0.j]
 ...
 [-0.+0.j 0.+0.j ... 0.+0.j -0.+0.j 0.+0.j]
 [0.+0.j -0.+0.j ... -0.+0.j 0.+0.j -0.+0.j]
 [-0.+0.j 0.+0.j ... 0.+0.j -0.+0.j 0.+0.j]]

dfs
[[0. +0.00000000e+00j 0. +0.00000000e+00j
 0. +0.00000000e+00j ... 0. +0.00000000e+00j
 0. +0.00000000e+00j 0. +0.00000000e+00j]
 [0. +0.00000000e+00j -0.0010452 -4.7720413e-05j
 0.00275052+1.01307553e-04j ... 0.00194638-4.77002466e-05j
 -0.00275218+3.37729663e-05j 0.00194579+0.00000000e+00j]
 [0. +0.00000000e+00j 0.00275052+1.01307553e-04j
 -0.00188805-1.01810466e-04j ... -0.00275383+1.37963239e-05j
 0.00389334+0.00000000e+00j -0.00275218-3.37729663e-05j]
 ...
 [0. +0.00000000e+00j 0.00194638-4.77002466e-05j
 -0.00275383+1.37963239e-05j ... -0.00194286+1.43313693e-04j
 0.00274886-1.68879844e-04j -0.00194462+0.55328679e-05j]
 [0. +0.00000000e+00j -0.00275218+3.37729663e-05j
 0.00389334+0.00000000e+00j ... -0.00274886-1.68879844e-04j
 -0.00188805+1.01810466e-04j 0.00275052-1.01307553e-04j]
 [0. +0.00000000e+00j 0.00194579+0.00000000e+00j
 -0.00275218-3.37729663e-05j ... -0.00194462+0.55328679e-05j
 0.00275052-1.01307553e-04j -0.0019452 -4.7720413e-05j]]

dimension of the vector- 128
[15.9375, 109.07300351173055, 139.51764169173128, 77.96110931220066, 5.744128417195991, 53.691181184069, 63.293141811806855, 45.3228265406743, 5.8342399384384525, 34.414906196385786, 43.05426128868283, 32.49800750678001, 6.845488305974484, 25.302208260755823, 35.783841983083, 24.668080540097333, 4.925657462469913, 1.06566882690057, 29.063629108362117, 21.241634705252, 4.118900828240281, 18.429572966328895, 24.151160725427726, 18.2064907665535, 4.1438226328395755, 16.402864034349134, 21.7456130312512, 15.6013314761, 76.114, 3.1256262615123647, 14.5072520819049176, 18.69851111768004, 12.400700809784508, 17.973966590461123, 12.939130441811393, 3.282709080243783, 11.55200493908308, 15.860814029036209, 12.562839556407056, 1.405527700017429, 10.9659921007056, 14.584630227786258, 11.769834041302148, 2.780959191811193, 0.92051140794306, 11.8621157902144, 10.442023621550874, 3.129697704664, 9.60671109417708, 13.51803168300820, 9.989645101390603, 2.2351342337517528, 9.207032224052042, 12.417205238, 988593, 9.84755576064702, 2.20890043020472, 8.901875561120183, 11.504523076223573, 9.377547512952766, 2.3311366500806545, 8.350467358562545, 11.41051816641248, 8.778238977674027, 2.257448238462199, 8.146827391354622, 10.66704846498549, 8.457434882923197, 2.3138, 710040638323, 7.72574262545385, 10.41830020415304, 7.9808450059421105, 2.201963140075635, 7.60808578207674, 10.1130377916939, 7.96126001196817, 2.1186422023934423, 7.401555425340789, 9.6159558004326, 7.80095042538023, 2.1159345013481386, 7.11591011570115, 9.70240630811567, 7.430035527350077, 2.220179101371114, 6.800807426272714, 9.423020701420767, 7.43800800207032, 1.433207022206165, 6.90613750474500, 8.904811436040207, 7.40754021541105, 2.4024040077145278, 6.65606264541185, 9.145326033457119, 6.864432000092720, 2.2.180323590203, 6.51247730578224, 9.04683065519791, 7.807793628323776, 1.7638263051089556, 6.679523954700675, 9.02411203840664, 6.725599596631166, 1.9419584493753868, 6.570707641304555, 8.673393900227007, 7.057712628260174, 1.8607136977597315, 6.4816438567, 97006, 8.582011838777307, 6.944358232598449, 1.8912768663281240, 6.4076155872365615, 8.731407805148883, 6.804729457374002, 2.0233208725918503, 6.358508760067306, 8.623340027981047, 6.775226716196541, 1.8796124000661555, 6.458125937171365, 8.701646469647313, 6.864, 59348084044, 1.370472985901306, 6.4111005671930610, 8.45337246135593, 32.902790452564205]]
```

Fig 3- Computation Performed with the input square 256 image

## Set of Rings Method - Frequency of histogram using set of rings for square256 image

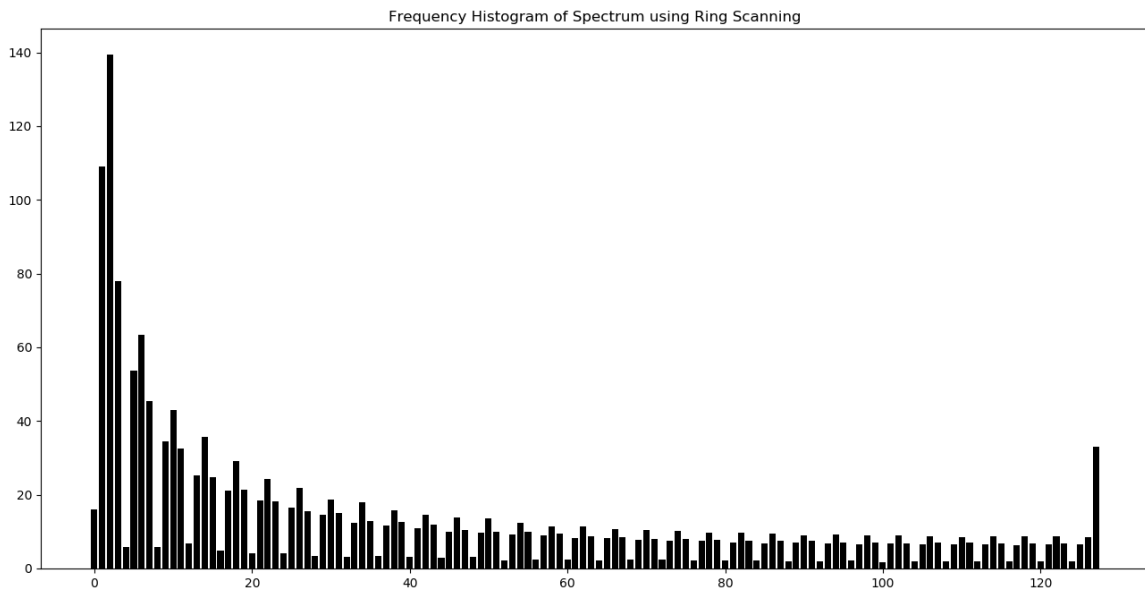


Fig 4- Frequency of histogram using set of rings for square256 image

2) B) divide the spectrum into angular sectors

## Angular Sector Method- Computation performed for car image

```
(base) C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\python "angularsector.py" "C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\input images\car.raw" 256 256 "C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\output"
here

original image
[[189 186 189 ... 173 183 178]
 [180 190 191 ... 180 185 174]
 [173 178 178 ... 187 186 159]
 ...
 [ 35 33 36 ... 89 85 81]
 [ 35 38 42 ... 88 85 78]
 [ 35 38 38 ... 88 90 82]]

complex image-
[[ 155.+0.j 156.+0.j 189.+0.j ... -173.+0.j 183.+0.j -178.+0.j]
 [-189.+0.j 190.+0.j -191.+0.j ... 189.+0.j -185.+0.j 174.+0.j]
 [ 173.+0.j -178.+0.j 178.+0.j ... -187.+0.j 186.+0.j -159.+0.j]
 ...
 [ -35.+0.j 33.+0.j -36.+0.j ... 89.+0.j -85.+0.j 81.+0.j]
 [ 35.+0.j -38.+0.j 42.+0.j ... -88.+0.j 85.+0.j -78.+0.j]
 [ -35.+0.j 38.+0.j -38.+0.j ... 88.+0.j -90.+0.j 82.+0.j]]

dft-
[[ 0.34765238e-03+0.00000000e+00j 4.10463518e-03+0.00137044j
  8.38668653e-03+0.00708937j ... 1.61404179e-03+0.0040226j
  8.38668653e-03+0.00708937j 4.10463518e-03+0.00137044j]
 [ 3.49852299e-03+0.00165883j -4.17999456e-03+0.0011206j
  1.54708424e-02+0.0027388j ... 3.08092127e-03+0.00131897j
  -8.31989461e-04+0.0031885j -6.87854557e-04+0.00838355j]
 [ 5.34636217e-03+0.00476163j -2.95489949e-03+0.00374931j
  4.87662775e-03+0.00418856j ... -4.67865758e-04+0.00578146j
  3.65597466e-03+0.00198576j 4.6412131e-04+0.00254768j]
 ...
 [ 7.35332380e-03+0.00134421j -7.96318365e-04+0.00200256j
  3.18572887e-03+0.00413325j ... -5.9527542e-03+0.00729827j
  4.63999293e-03+0.00089872j 4.28562183e-03+0.00572222j]
 [ 5.34636217e-03+0.00476163j 4.6412131e-04+0.00254768j
  3.65597466e-03+0.00198576j ... -3.48083018e-03+0.00416798j
  4.87662775e-03+0.00418856j -2.95489949e-03+0.00374931j]
 [ 3.49852299e-03+0.00165883j -6.87854557e-04+0.00838355j
  -8.31989461e-04+0.0031885j ... -9.85479635e-04+0.00682212j
  1.54708424e-03+0.0027388j -4.17999456e-03+0.0011206j]]

Angular histogram
[16.683786143162855, 18.64513796888902, 20.174078831573294, 21.576797366388838, 25.855141968263467, 22.587048528618535, 22.253119682673692, 19.934612572932857, 19.41388984836341, 25.327485281776882, 20.873854243924734, 20.17344745888623, 20.63559325449159, 21.539
80840749482, 21.99481584273789, 42.876357847015315, 20.22547488477847, 21.746467782515968, 24.498625218948783, 25.888953388986544, 23.897721865692211, 21.627728766532286, 27.875123819513172, 22.973677153298377, 23.637919881379793, 32.85395783417821, 28.64257936
483897, 35.86633229488765, 39.836578618649456, 41.624728839941, 57.745594206332, 158.47318698695915, 46.88157792215881, 40.1981911824514, 41.64033363161369, 51.538212038890, 63.54243786337646, 35.9584132888819, 32.8662096238889, 21.58838253409889, 21.7
35184863738885, 33.37183415184815, 23.7166693718886, 23.8611816247851, 17.82619684298728, 24.65572732136488, 21.655522434082854, 34.2659514807748, 17.875218411325668, 22.588619422335347, 23.788556468613454, 24.975173386249253, 23.53855656681825, 20.291173310
825997, 27.821885518784532, 23.873479514119842, 25.136713426968387, 25.958182118391766, 22.56880995557179, 18.874284246843515, 19.154685276525886, 20.856178352218543, 20.10341881465767, 40.24785981284888, 15.57858528148542, 18.814224872666756, 19.256583699531447,
22.51535224881567, 25.63281744778079, 21.7487286742337, 23.21881666473695, 20.32822484039196, 10.465228539372253, 25.581614819453653, 21.12888627688338, 20.211471815654624, 18.512370171781812, 23.68781169787285, 21.383895982463114, 40.48888778888825, 18.6933
0124526383, 22.226881785926465, 24.292235573363, 25.443114385371188, 22.67827297292256, 21.254796777113127, 27.998526145629928, 23.044055471679753, 23.696345351566646, 31.185634359325375, 30.11889292393632, 34.82377837481782, 36.69381567732481, 42.31793628853
746, 56.32878163682279, 162.835688818631, 43.41202265685627, 40.661719328891365, 39.83413483584743, 53.496199924697472, 63.5253996411346, 36.8508182971238, 32.25239211496709, 22.231533618888818, 21.779219783099574, 33.488781339285926, 24.228858852562383, 23.4547
4466853182, 18.131373779193, 23.608118948884, 21.03293975117894, 88.297867424865915, 15.8889948871832, 22.728117874451125, 23.846087885169425, 20.562896349343484, 28.02111596377829, 19.294158843821314, 28.00165811792311, 23.138666813727555, 23.91172938766097,
27.453877212729355, 18.50871544245817, 22.76555396893888, 19.58282125558413, 19.826519288623568, 19.71869493854455, 41.54038884752431]
```

Fig 5 - Computation performed for car image using angular sector method

## Frequency histogram for car using angular method

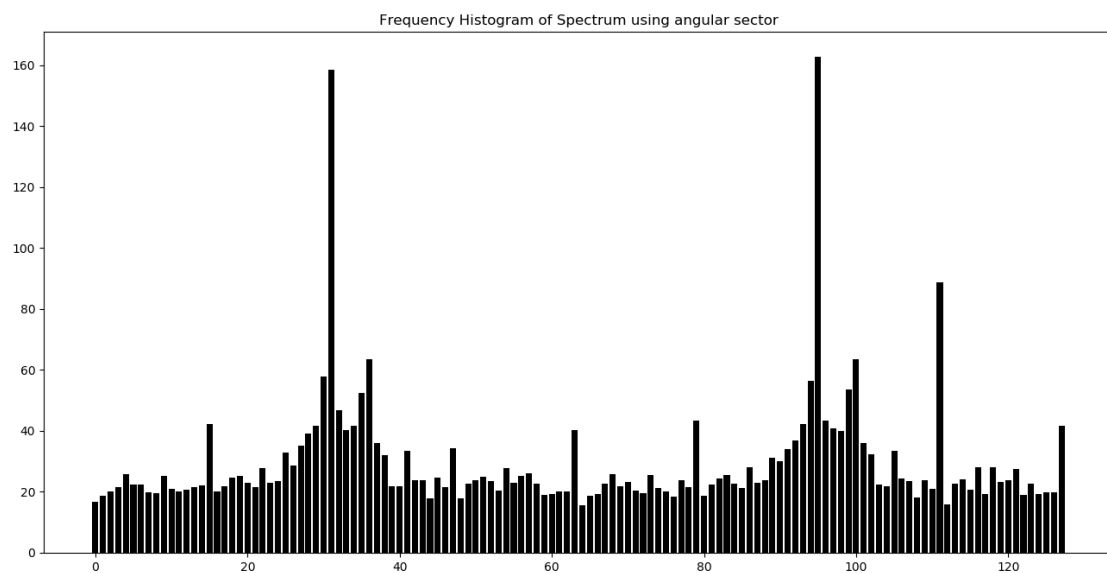


Fig 6- Frequency histogram for car using angular method

## Angular Sector Method - Computation performed for square256 image

```
(base) C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\python "angularsector.py" "C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\input images\square256.raw" 256 256 "C:\Users\Owner\Desktop\Image Processing\assignment 4 part 2\output here"

original image
[[0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 ...
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]]

complex image-
[[-0.40j -0.40j 0.40j ... -0.40j 0.40j -0.40j]
 [-0.40j 0.40j -0.40j ... 0.40j -0.40j 0.40j]
 [0.40j -0.40j 0.40j ... -0.40j 0.40j -0.40j]
 ...
 [-0.40j 0.40j -0.40j ... 0.40j -0.40j 0.40j]
 [0.40j -0.40j 0.40j ... -0.40j 0.40j -0.40j]
 [-0.40j 0.40j -0.40j ... 0.40j -0.40j 0.40j]]

dft-
[[ 0. +0.00000000e+00j 0. +0.00000000e+00j
  0. +0.00000000e+00j ... 0. +0.00000000e+00j
  0. +0.00000000e+00j 0. +0.00000000e+00j
  [ 0. +0.00000000e+00j -0.0019452 -4.77520433e-05j
    0.00275952+1.01307553e-04j ... 0.00194638 -4.77002466e-05j
    -0.00275218-1.37759663e-05j 0.00194579+0.00000000e+00j]
  [ 0. +0.00000000e+00j 0.00275952+1.01307553e-04j
    -0.00188865 -1.51830946e-04j ... -0.00275383+3.37963239e-05j
    0.00189334+0.00000000e+00j -0.00275218-1.37759663e-05j]
  ...
  [ 0. +0.00000000e+00j 0.00194638 -4.77002466e-05j
    -0.00275383+3.37963239e-05j ... -0.00194286+1.43113093e-04j
    0.00274886 -1.68870044e-04j -0.00194462+9.55328079e-05j]
  [ 0. +0.00000000e+00j -0.00275218+3.37759663e-05j
    +0.00000000e+00j ... 0.00275218+3.37759663e-05j
    0.00189334+0.00000000e+00j ... 0.00274886 -1.68870044e-04j
    -0.00188865 -1.51830946e-04j 0.00275952+1.01307553e-04j]
  [ 0. +0.00000000e+00j 0.00194579+0.00000000e+00j
    -0.00275218-1.37759663e-05j ... -0.00194462+9.55328079e-05j
    0.00275952 -1.01307553e-04j -0.0019452 -4.77520433e-05j]]

Angular histogram
[42.40868565680881, 20.871583957114048, 14.810081674263027, 14.878455922091589, 6.224127445406828, 6.803140397290056, 11.00181307325257, 5.437336668636151, 4.377671107252141, 13.584362997423675, 4.577612703315667, 6.246110579041532, 3.3074467575535036, 3.07456168
77408876, 3.933523517866088, 25.835858339418532, 2.767612938258863, 3.77266623267195, 2.98174839978866, 6.744561363618581, 4.211759791717695, 3.43813927023911, 13.593053018248888, 4.2966604815456435, 5.75620970493219, 11.450245077565555, 6.003762223539374, 10
.932424100770396, 13.94845220817307, 13.55536680899761, 24.571765027619913, 100.21302540281015, 40.81054113396544, 21.70230842326923, 14.54014620531256, 14.88080054457633, 6.202146470266655, 6.718427192090875, 11.11471759763327, 5.47933856520370, 4.340550
1317590405, 13.403830852782485, 4.536734288051259, 6.282611448244628, 3.377997075697336, 3.0241420173026113, 3.9387571320863125, 25.842068743079427, 2.6778552056700162, 3.78741533002777, 2.8459112126253383, 6.888135280419398, 4.150105920742680, 3.4013090883335825
, 13.49624525819331, 4.642016561272305, 5.77641247411267, 11.41197443073978, 5.898132348294069, 10.974408396493675, 10.753884349150132, 16.670328075488256, 23.486195866804515, 109.57818091451053, 40.32080958494374, 21.937315212079632, 13.9108465816614, 14.94725
21936809, 6.76805213443175, 6.87513056517255, 11.122539014159886, 5.3082991219778, 4.352306578210831, 13.66800783146065, 4.53350435562024, 6.269017107018128, 3.43110848223066, 2.9581798435038262, 3.942203558777127, 25.90576583927425, 2.434671355401145, 3.968
703083360946, 2.8020700631774145, 6.95015075148029, 4.122483310432308, 3.202706021385077, 13.50753407031502, 4.375471160802245, 5.600700803794004, 10.82542321470805, 6.55501117083307, 10.838375031835564, 10.70703631311008, 16.35066633342400, 22.70216500815
156, 110.92991708073164, 38.643948835073196, 21.378454770089464, 13.912845100447273, 15.114707120325976, 6.1187790820421122, 6.899571425623444, 11.047447908756496, 5.523496111114599, 4.245626809260895, 13.505078374877236, 4.7949313434007825, 6.24064794910112, 3.39
6790030343415, 2.919391399629219, 3.819270052342244, 42.102231846153084, 2.372367081740585, 3.7008173251529507, 2.954740873274934, 3.32626632304754, 7.818172147264222, 3.2090729111424214, 13.605581276388474, 4.1755863974816565, 5.503482510039289, 11.221717481242
909, 6.65730267265747, 10.424887647315004, 10.572916063016033, 16.425507434775307, 21.336619666081864, 112.4394535312111]
```

Fig 7- Computation performed for square256 image using angular sector method

## Angular Sector Method - Frequency histogram for square 256

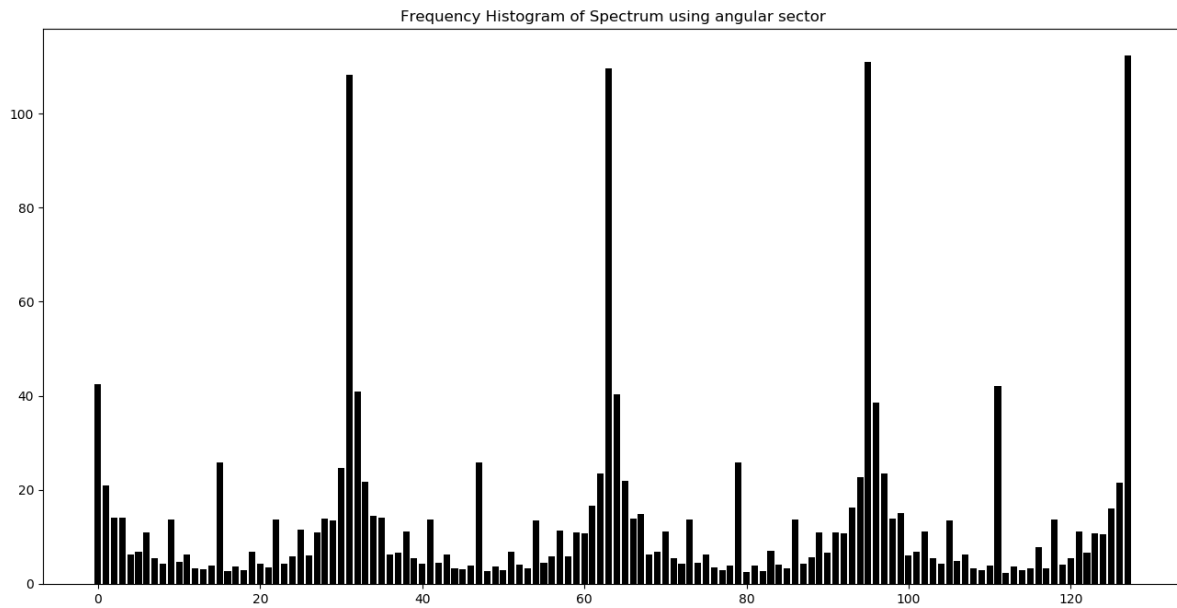


Fig 8 - Frequency histogram for square 256 using angular sector method

### Question 3)

Below Screenshots include raw pixel images and computations performed. Low pass filter is performed with the cut off frequencies 30 and 70 for both car and square images. High pass filter is performed with the cut off frequencies 10 and 60 for both car and square images.

Below screenshots consists 8 executions. For every execution, there is a screenshot of raw image, screenshot of the filter and screenshot of the inverse fft performed.

### Low pass filter

#### Low pass filter for car with the cutoff frequency 30



Fig 9- Low pass filter for car with the cutoff frequency 30

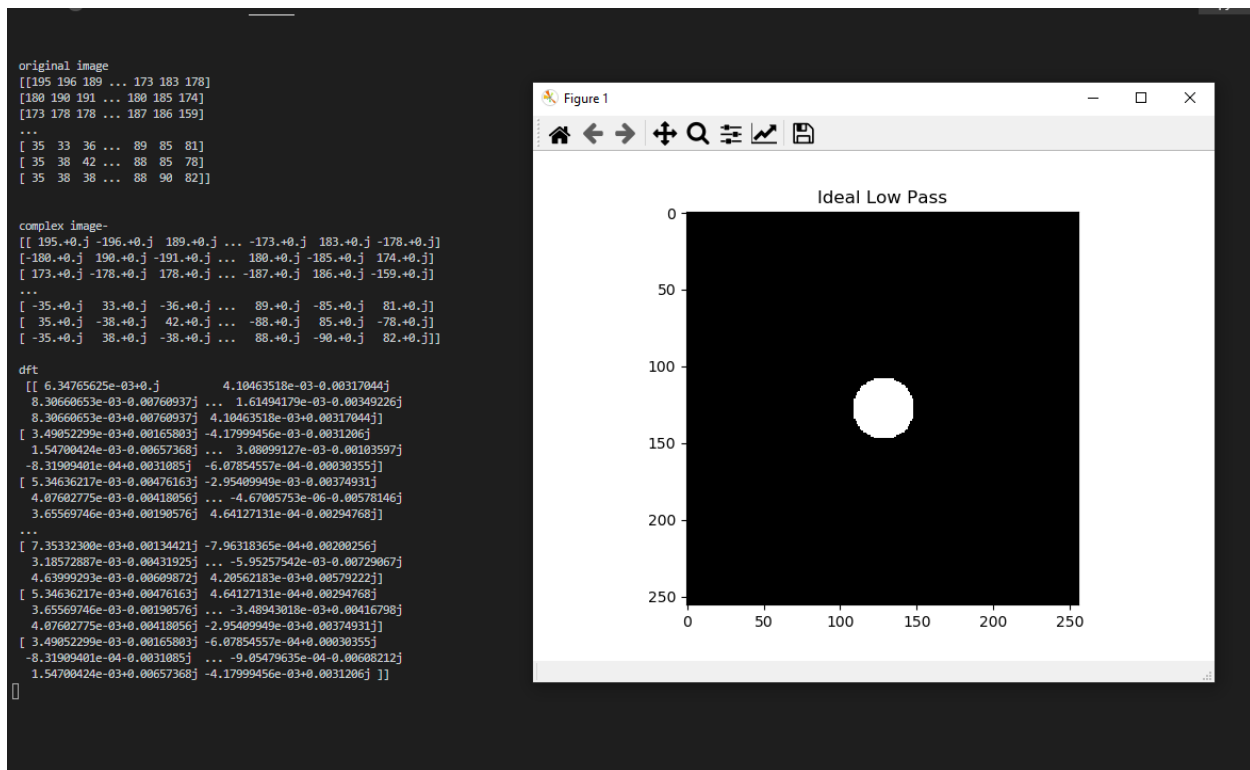


Fig 10- Low pass filter for the car with the cut off frequency 30

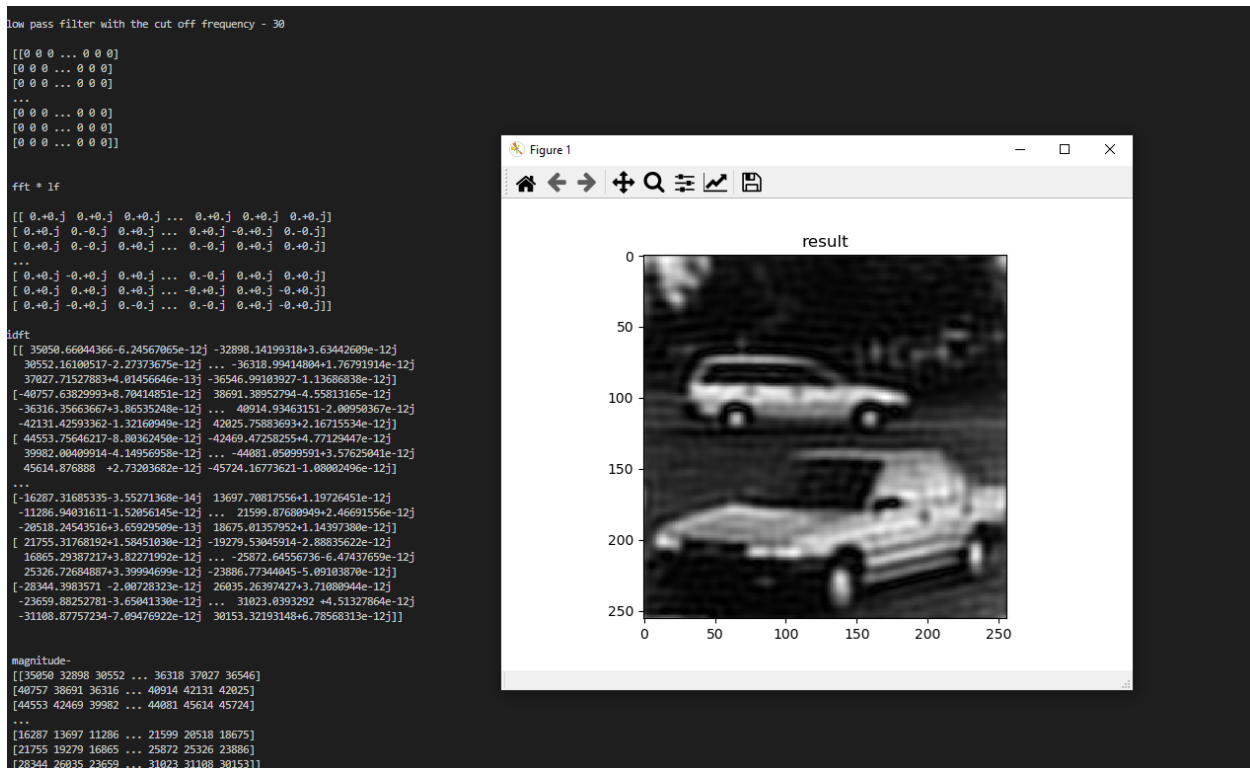


Fig 11- Low pass filter inverse fft result for the car with the cut off frequency 30



## Low pass filter for the car with the cut off frequency 70



Fig 12- Low pass filter for the car with the cut off frequency 70

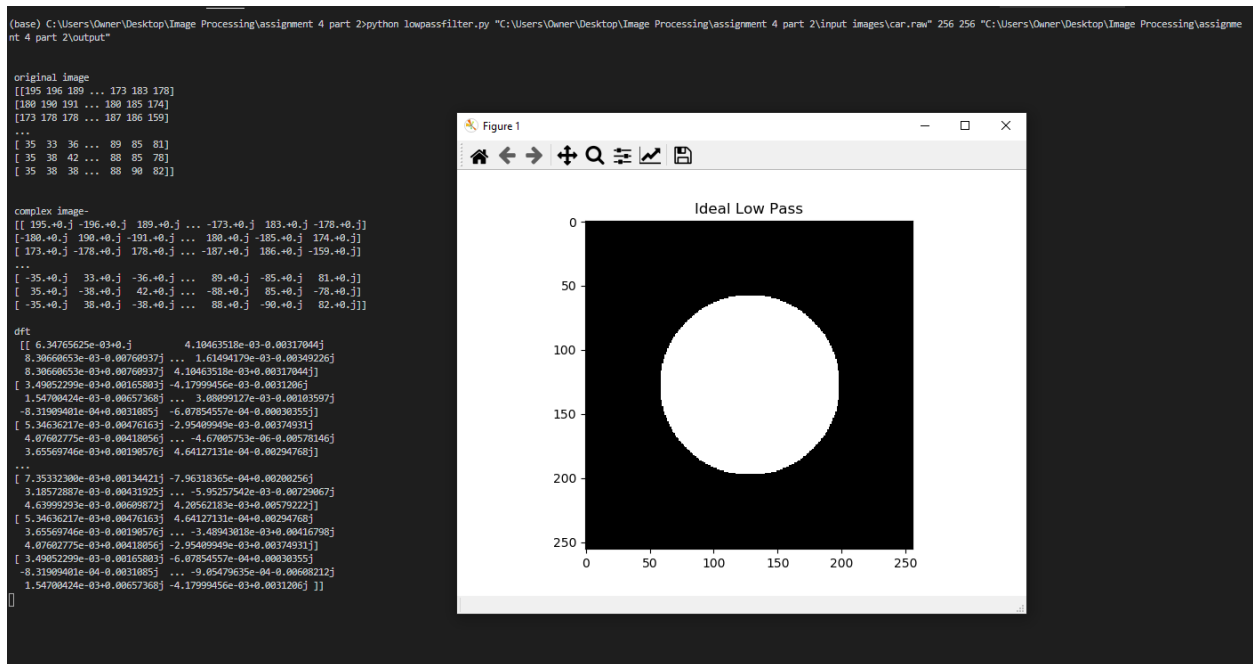


Fig 13- Low pass filter for the car with the cut off frequency 70

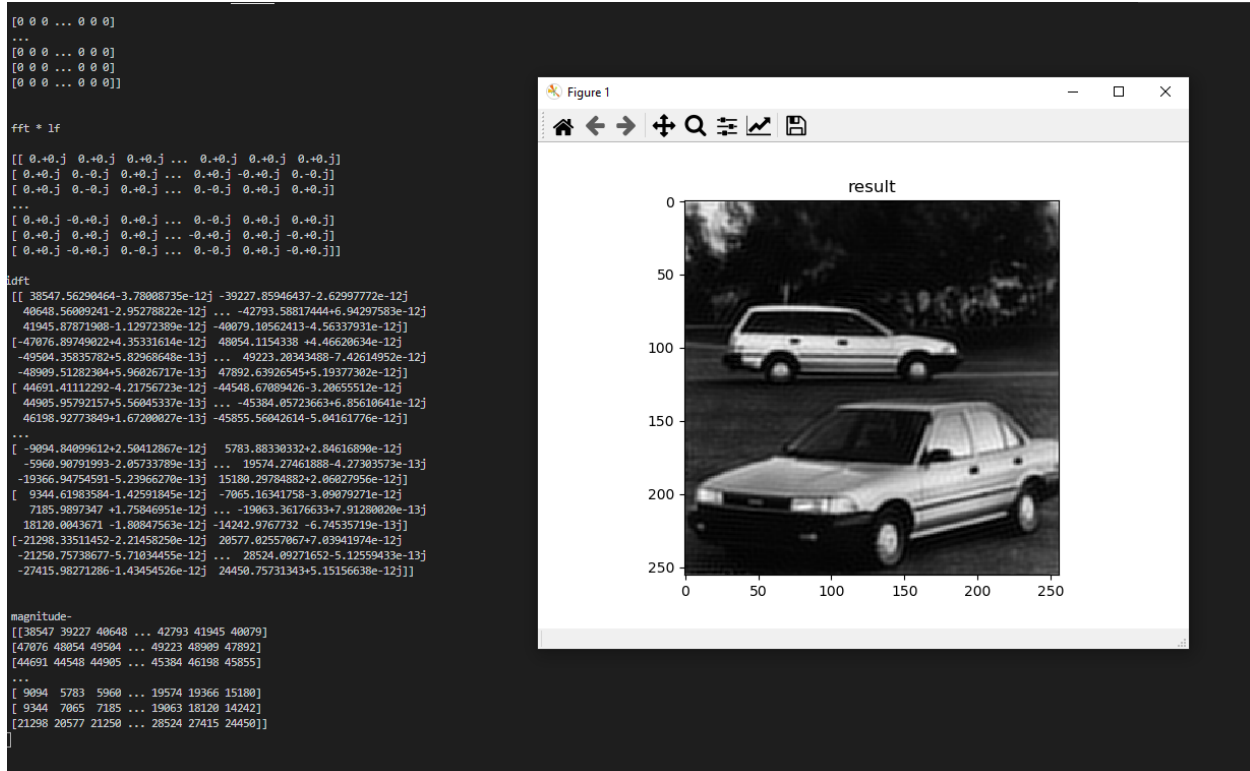


Fig 14- Low pass filter inverse fft result for the car with the cut off frequency 70

### Low pass filter for the square with the cut off frequency 30

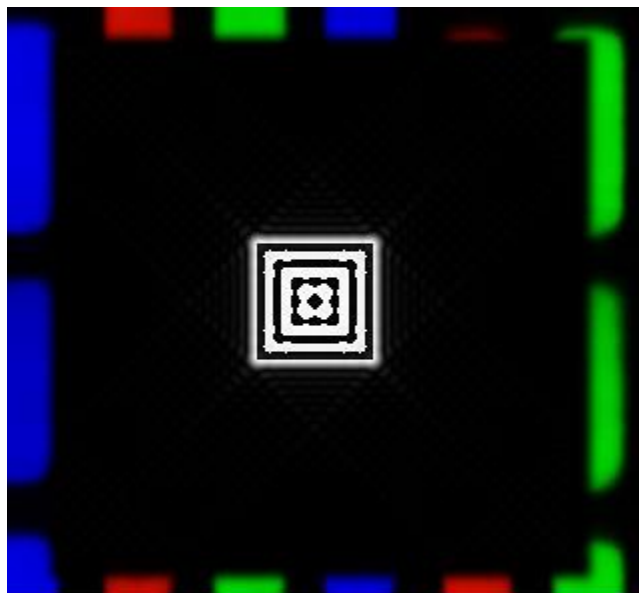


Fig 15 - Low pass filter for the square with the cut off frequency 30

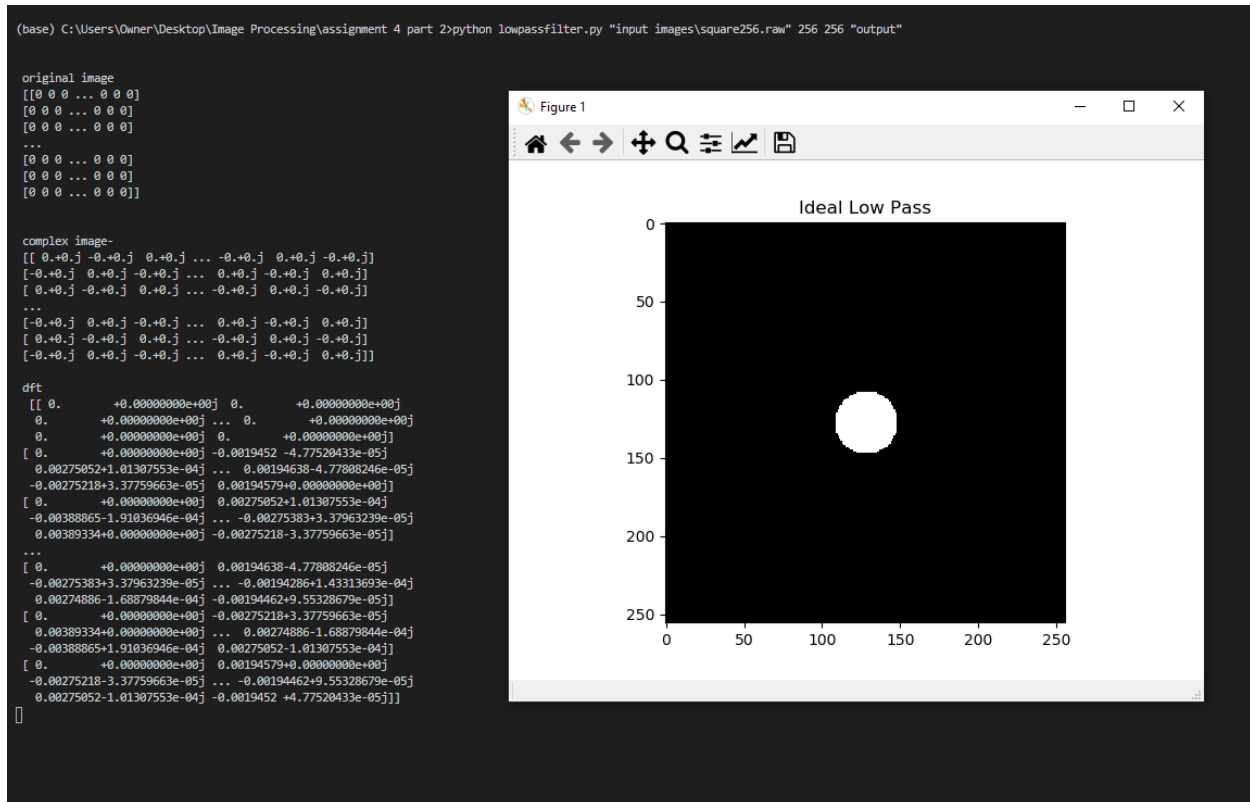


Fig 16- Low pass filter for the square with the cut off frequency 30

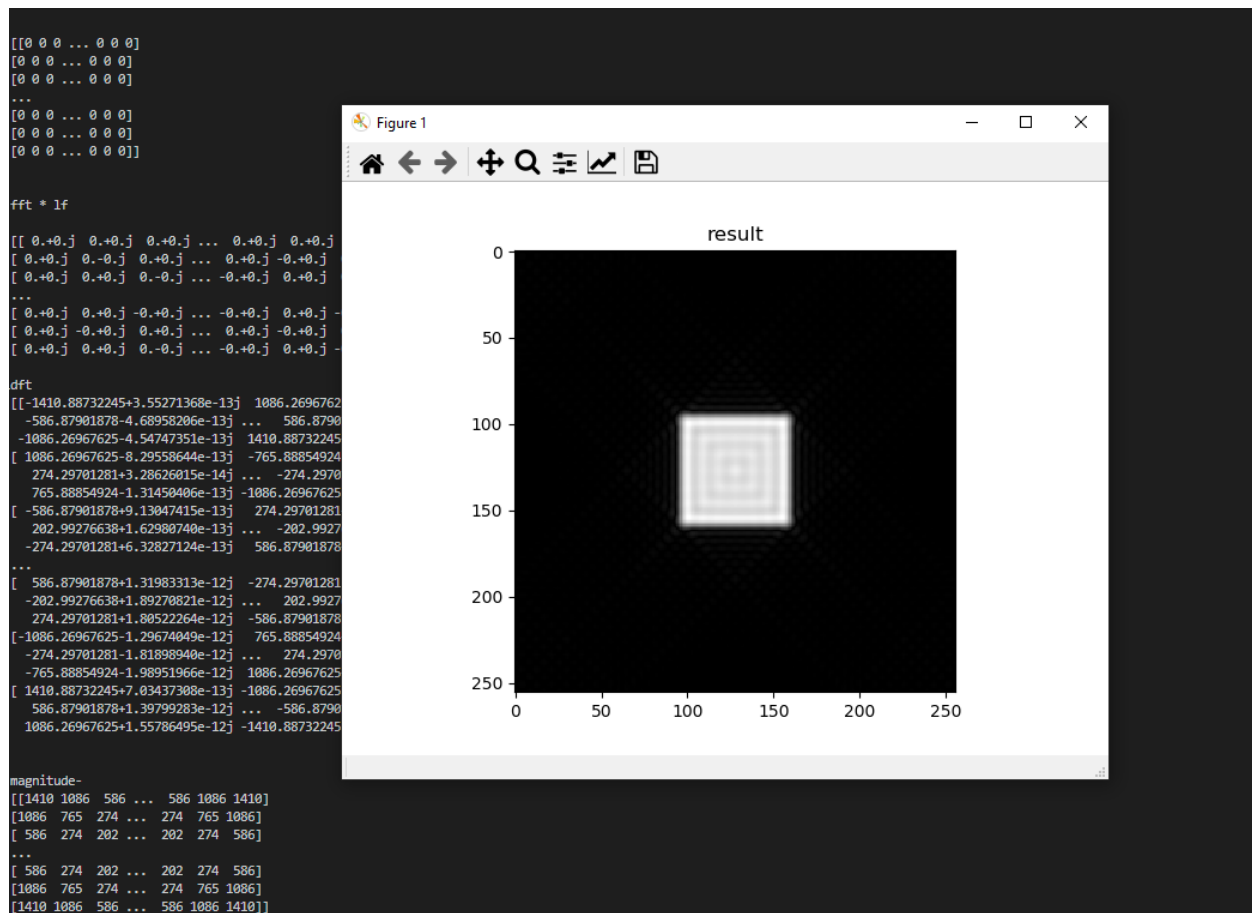


Fig 17- Low pass filter inverse fft result for the square with the cut off frequency 30

## Low pass filter for the square with the cut off frequency 70

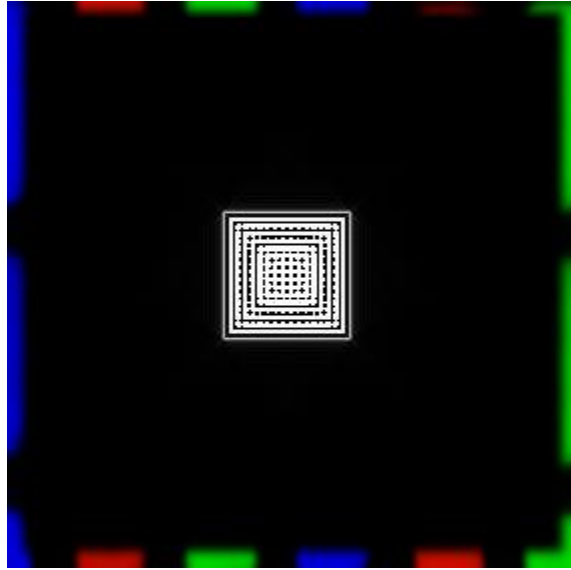


Fig 18 - Low pass filter for the square with the cut off frequency 70

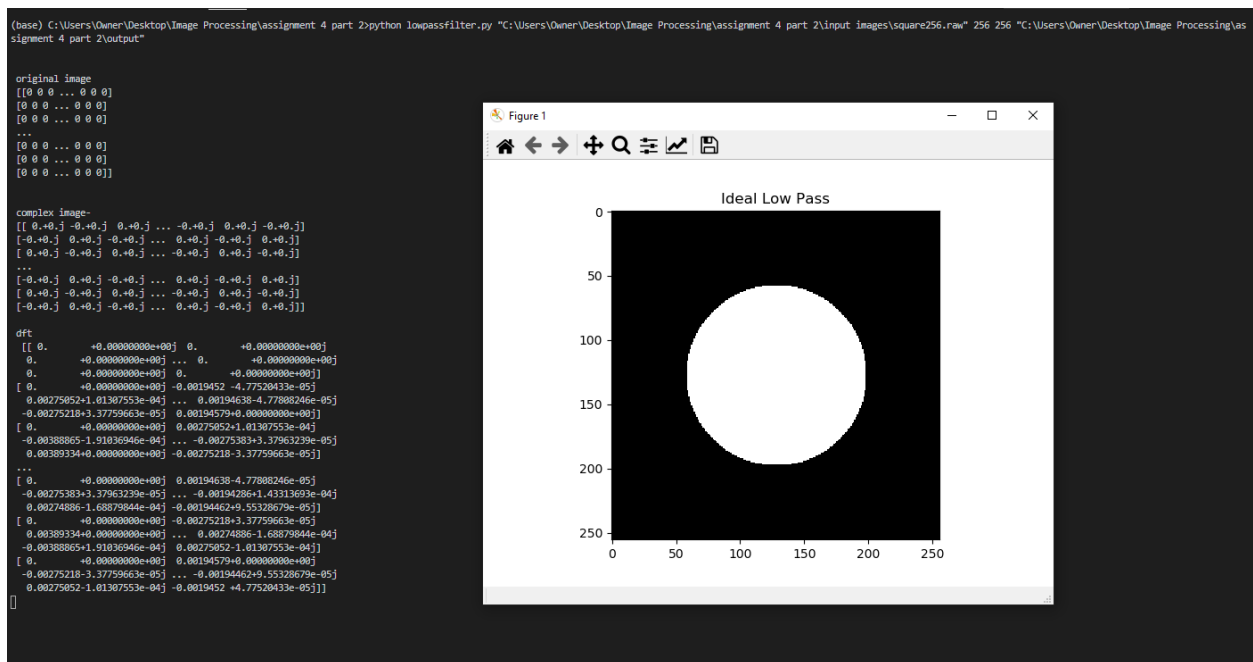


Fig 19- Low pass filter for the square with the cut off frequency 70

```

[[0 0 0 ... 0 0 0]
[0 0 0 ... 0 0 0]
[0 0 0 ... 0 0 0]
...
[0 0 0 ... 0 0 0]
[0 0 0 ... 0 0 0]
[0 0 0 ... 0 0 0]]

fft * 1f

[[ 0.+0.j 0.+0.j 0.+0.j ... 0.+0.j 0.+0.j 0.+0.j]
[ 0.+0.j 0.-0.j 0.+0.j ... 0.+0.j -0.+0.j 0.+0.j]
[ 0.+0.j 0.+0.j 0.-0.j ... -0.+0.j 0.+0.j 0.-0.j]
...
[ 0.+0.j 0.+0.j -0.+0.j ... -0.+0.j 0.+0.j -0.+0.j]
[ 0.+0.j -0.+0.j 0.+0.j ... 0.+0.j -0.+0.j 0.+0.j]
[ 0.+0.j 0.+0.j 0.-0.j ... -0.+0.j 0.+0.j -0.+0.j]]

dft
[[-537.92360614+2.84217094e-14j -22.80696135+5.40012479e-13j
 -6.59820005+2.05346851e-12j ... 6.59820005+1.64135372e-12j
 22.80696135-1.73372428e-12j 537.92360614+1.13686838e-13j]
[-22.80696135+2.02060590e-14j 541.9389369 -5.10702591e-13j
 -461.84456044-1.83408844e-12j ... 461.84456044-1.49924517e-12j
 -541.9389369 +1.24256161e-12j 22.80696135-1.46549439e-13j]
[-6.59820005+1.79856130e-13j -461.84456044+6.71462885e-13j
 331.53721932+1.55697677e-12j ... -331.53721932+1.80033766e-12j
 461.84456044-9.84101689e-13j 6.59820005+3.39506201e-13j]
...
[ 6.59820005+1.33693057e-12j 461.84456044-1.40687462e-12j
 -331.53721932-1.43351997e-12j ... 331.53721932-2.90434343e-12j
 -461.84456044+3.70548037e-12j -6.59820005-8.98392472e-13j]
[ 22.80696135-1.16218146e-12j -541.9389369 +1.39799283e-12j
 461.84456044+1.67332814e-12j ... -461.84456044+2.84927637e-12j
 541.9389369 -3.33244543e-12j -22.80696135+8.11350986e-13j]
[ 537.92360614+6.32383035e-13j 22.80696135-1.06825659e-12j
 6.59820005-1.85884641e-12j ... -6.59820005-2.44838123e-12j
 -22.80696135+2.61546340e-12j -537.92360614-5.75539616e-13j]]

magnitude=
[[537 22 6 ... 6 22 537]
[ 22 541 461 ... 461 541 22]
[ 6 461 331 ... 331 461 6]
...
[ 6 461 331 ... 331 461 6]
[ 22 541 461 ... 461 541 22]
[537 22 6 ... 6 22 537]]

```

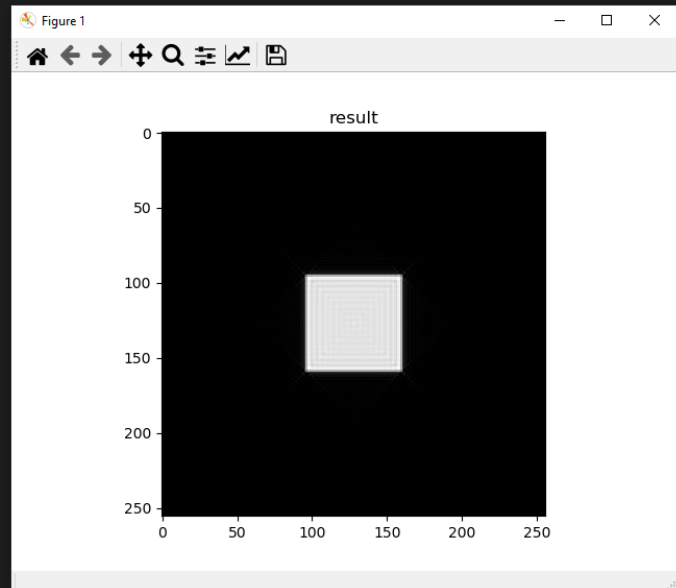


Fig 19- Low pass filter inverse fft result for the square with the cut off frequency 70

## High Pass Filter

High pass filter for the car with the cut off frequency 10



Fig 20- High pass filter for the car with the cut off frequency 10

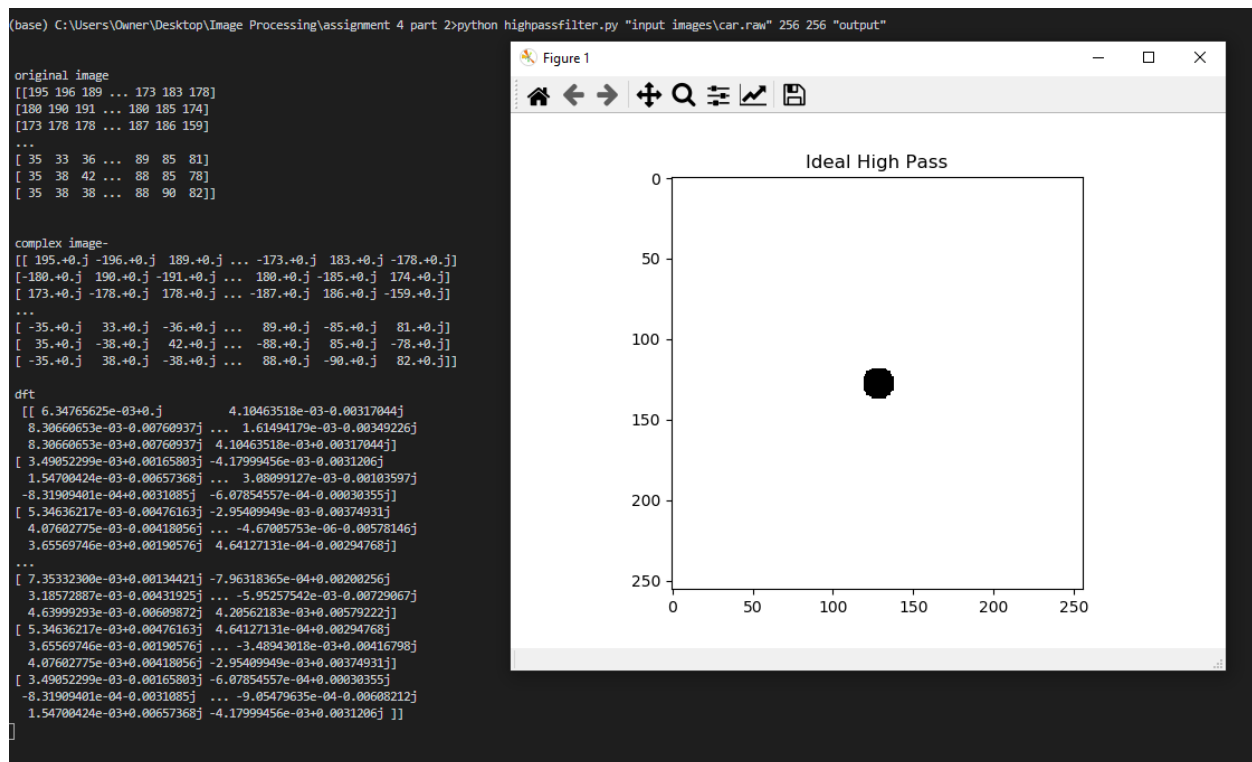


Fig 21- High Pass Filter for the car with the cut off frequency 10

High pass filter with the cut off frequency - 10

```
[[255 255 255 ... 255 255 255]
 [255 255 255 ... 255 255 255]
 [255 255 255 ... 255 255 255]
 ...
 [255 255 255 ... 255 255 255]
 [255 255 255 ... 255 255 255]
 [255 255 255 ... 255 255 255]]
```

fft \* hf

```
[[ 1.61865234e+00+0.0j          1.04668197e+00-0.808463j
  2.11818467e+00-1.94038851j ... 4.11810157e-01-0.89052738j
  2.11818467e+00+1.94038851j          1.04668197e+00+0.808463j ]
 [ 8.90083363e-01+0.42279652j -1.06589861e+00-0.79575375j
  3.94486082e-01-1.67628742j ... 7.85652774e-01-0.26417341j
 -2.12136897e-01+0.79266721j -1.55002912e-01-0.07740426j]
 [ 1.36332235e+00-1.21421522j -7.53295370e-01-0.95607301j
  1.03938708e+00-1.06604163j ... -1.19086467e-03-1.47427253j
  9.32202852e-01+0.48596902j          1.18352418e-01-0.75165813j]
 ...
 [ 1.87509737e+00+0.3427729j -2.03061183e-01+0.51065352j
  8.12360862e-01-1.10140952j ... -1.51790673e+00-1.85912086j
  1.18319820e+00-1.55517442j          1.07243357e+00+1.47781544j]
 [ 1.36332235e+00+1.21421522j          1.18352418e-01+0.75165813j
  9.32202852e-01-0.48596902j ... -8.89804696e-01+1.06283588j
  1.03938708e+00+1.06604163j -7.53295370e-01+0.95607301j]
 [ 8.90083363e-01-0.42279652j -1.55002912e-01+0.07740426j
 -2.12136897e-01-0.79266721j ... -2.36897307e-01-1.55093954j
  3.94486082e-01+1.67628742j -1.06589861e+00+0.79575375j]]
```

idft

```
[[ 26141.41129065+2.59881006e-12j -26366.44921647-3.57677877e-12j
  24535.11201001+6.45816107e-13j ... -20706.24409187+4.12206280e-
  23165.28850126-1.62370055e-12j -21838.12379189+2.09722964e-12j]
 [-21545.00794106+2.51199743e-14j 23960.00273953+2.18024111e-12j
 -24060.5051332 +5.18430107e-14j ... 22014.85760175-9.21271122e-
 -23104.00661433-9.69957460e-13j 20140.47980429-3.27639051e-12j]
 [ 19131.09157323+6.17043271e-12j -20169.74233306 -6.96445267e-12j
 19910.51025043+2.97574912e-12j ... -23453.28260623+7.30248967e-
 22922.01610173+1.65964595e-12j -15792.35553419+3.93086497e-13j]
 ...
 [ 11714.72303676-3.04442464e-12j -11935.77831551+2.33354009e-13j
 10890.621718 -5.32578389e-13j ... 1323.0091994 -3.25747491e-
 -505.90111734+2.93002759e-12j -263.04546731+3.82904581e-13j]
 [-12775.00719747-2.08125927e-12j 11826.93525531+2.19831873e-12j
 -10634.07903658-3.24198186e-12j ... -307.51590668+5.81063003e-12j
 -352.29592637-4.92125790e-12j 1987.23987428+4.85297604e-12j]
 [ 13765.82783332-9.52378244e-13j -12923.87533965-8.79798780e-13j
 12860.46915855-1.55234211e-12j ... -378.33682182-5.95632290e-12j
```

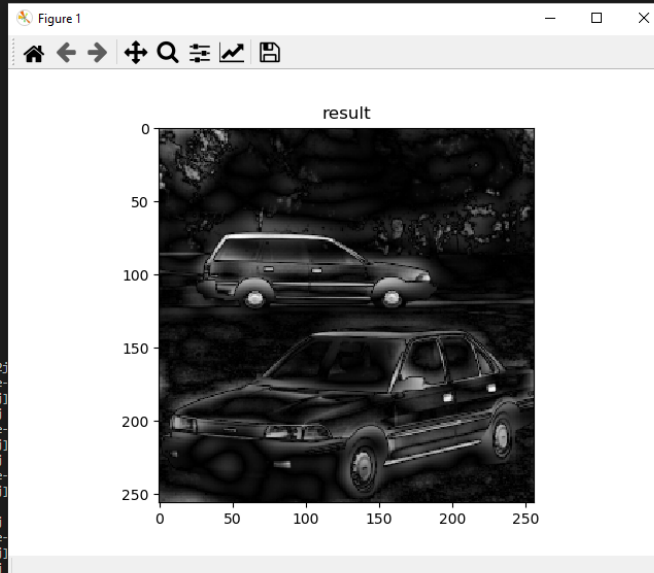


Fig 22- High Pass Filter inverse fft result for the car with the cut off frequency 10



## High pass filter for the car with the cut off frequency 60



Fig 23 - High pass filter for the car with the cut off frequency 60

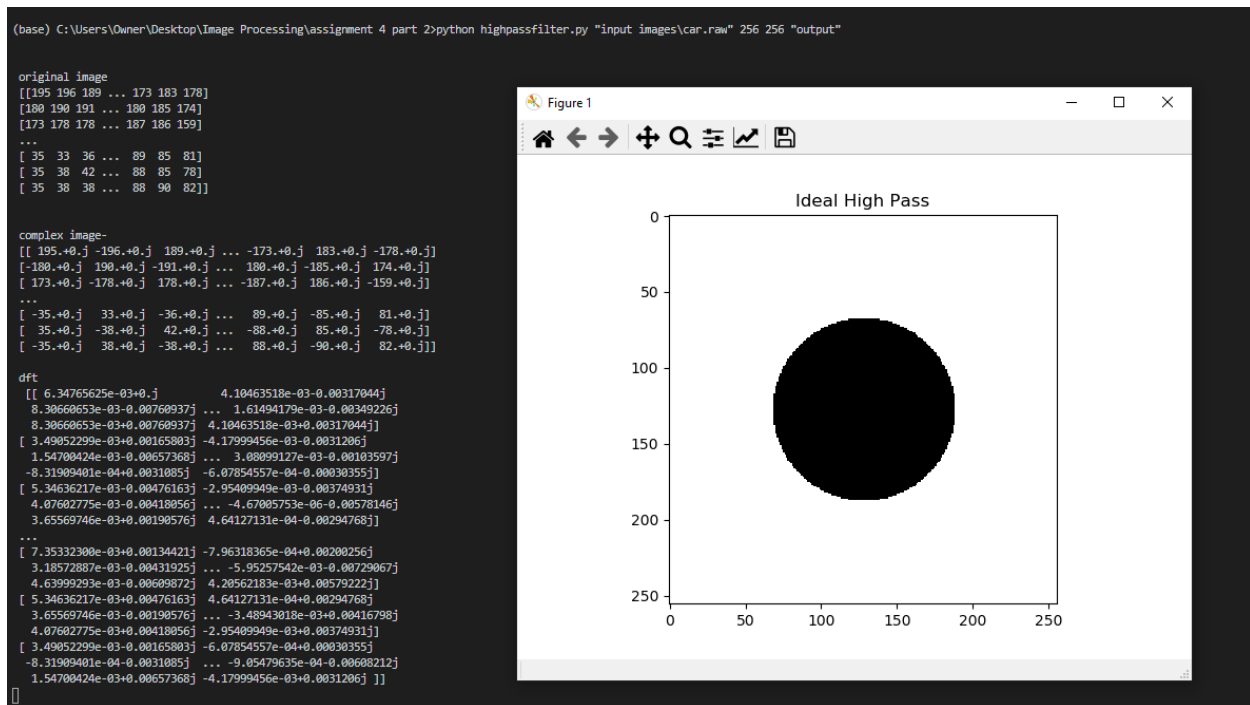


Fig 24- High Pass Filter for the car with the cut off frequency 60

```

[[255 255 255 ... 255 255 255]
[255 255 255 ... 255 255 255]
[255 255 255 ... 255 255 255]
...
[255 255 255 ... 255 255 255]
[255 255 255 ... 255 255 255]
[255 255 255 ... 255 255 255]]

```

```
fft * hf
```

```

[[ 1.61865234e+00+0.0j      1.04668197e+00-0.808463j
  2.11818467e+00-1.94038851j ... 4.11810157e-01-0.89052738j
  2.11818467e+00+1.94038851j 1.04668197e+00+0.808463j ]
[ 8.90083363e-01+0.42279652j -1.06589861e+00-0.79575375j
  3.94436882e-01-1.67628742j ... 7.85652774e-01-0.26417341j
 -2.12136897e-01+0.79266721j -1.55002912e-01-0.07740426j]
[ 1.36332235e+00-1.21421522j 7.53295370e-01-0.95687383j
  1.03938788e+00-1.06604163j ... -1.19086467e-03-1.47427253j
  9.32202852e-01+0.48596902j 1.18352418e-01-0.75165813j]
...
[ 1.87509737e+00+0.3427729j  -2.03061183e-01+0.51065352j
  8.12360862e-01-1.10140952j ... -1.51790673e+00-1.85912086j
  1.18319820e+00-1.55517442j 1.07243357e+00+1.47701544j]
[ 1.36332235e+00+1.21421522j 1.18352418e-01+0.75165813j
  9.32202852e-01-0.48596902j ... -8.89004696e-01+1.06283588j
  1.03938788e+00+1.06604163j -7.53295370e-01+0.95687381j]
[ 8.90083363e-01-0.42279652j -1.55002912e-01-0.07740426j
 -2.12136897e-01-0.79266721j ... -2.30097307e-01-1.55093954j
  3.94436882e-01+1.67628742j -1.06589861e+00+0.79575375j]]

```

```
idft
```

```

[[ 12088.02052181+2.46247467e-12j -13304.30441343-4.30850803e-13j
 11258.51330255-2.32787721e-12j ... -3130.48350105-2.04145134e-12j
 6300.4124143 -9.27407725e-13j -6201.13590227+2.28641165e-12j]
[ 1531.48583291-2.41959113e-12j 1607.26370395-2.24821650e-12j
 -1589.25489965+1.99702571e-12j ... -1945.10981882-2.18544356e-12j
 1142.32205494+7.81321349e-14j -3826.81298188-5.90628681e-12j]
[ -3425.56189796+5.75091323e-12j 774.39276639-1.63569003e-12j
 43.59734439-1.27795332e-12j ... -665.34632275-4.83370535e-13j
 -839.29686411+1.14937025e-12j 7905.02975581+1.66634991e-12j]
...
[ 806.66983008-2.18333567e-12j 2323.50034259+1.35654383e-13j
 -4614.49507101+9.63186032e-13j ... 4134.65039743+6.67385522e-13j
 -4274.54990962-1.01788004e-12j 6456.44388928+3.85301767e-12j]
[ -2862.1795872 -7.40698767e-13j -1042.76593978+1.28557920e-12j
 3350.86074902-2.12369316e-12j ... -1878.06143458+9.58599496e-13j
 2804.95504589+1.51619837e-12j -4139.20501927-1.55218228e-12j]
[ 13633.96482901+8.11100000e-13j -10786.60427138-3.52123340e-12j
 10267.00764288+3.26165688e-12j ... -6890.38521357-2.58813628e-12j
 4867.80093255+1.28921832e-12j -4519.78648867-1.34053885e-12j]]

```

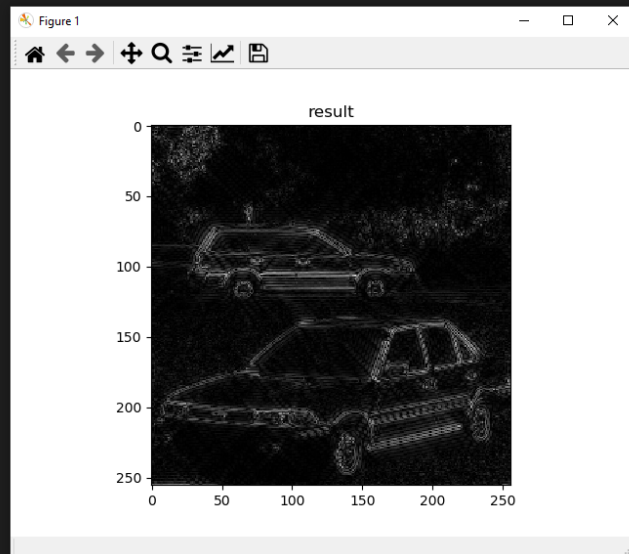


Fig 25- High Pass Filter for the car with the cut off frequency 60

## High pass filter for the square with the cut off frequency 10



Fig 26- High pass filter for the square with the cut off frequency 10

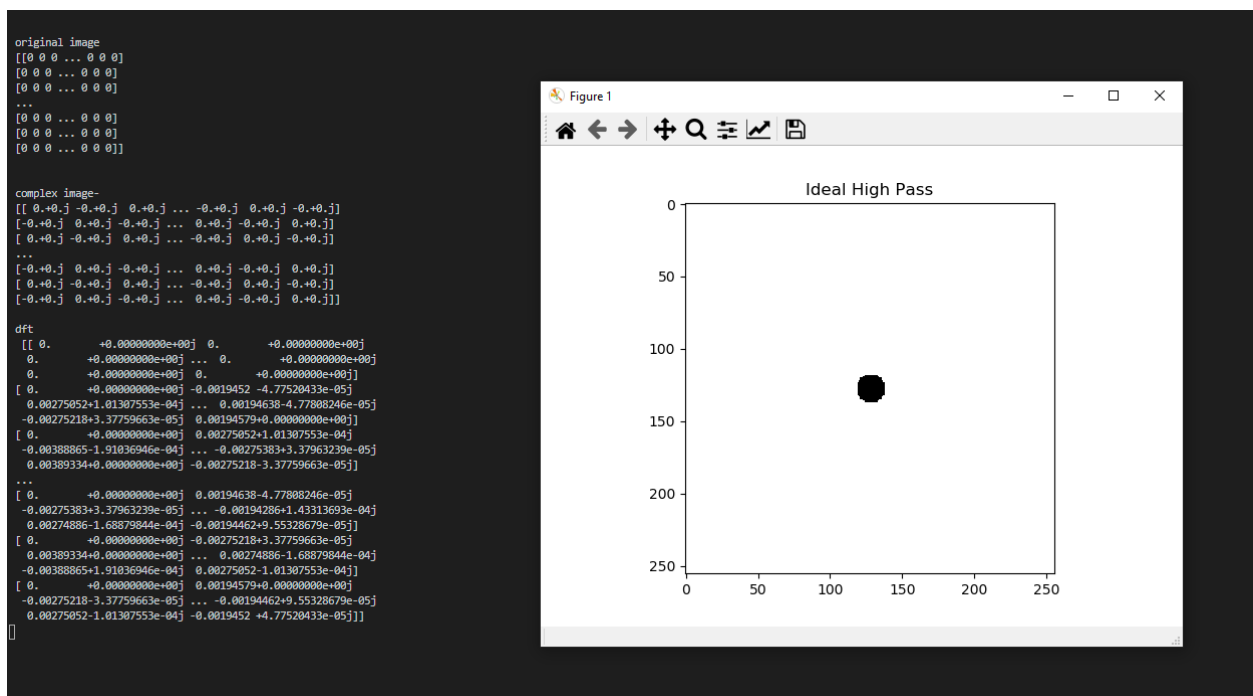


Fig 27- High Pass Filter for the square with the cut off frequency 10

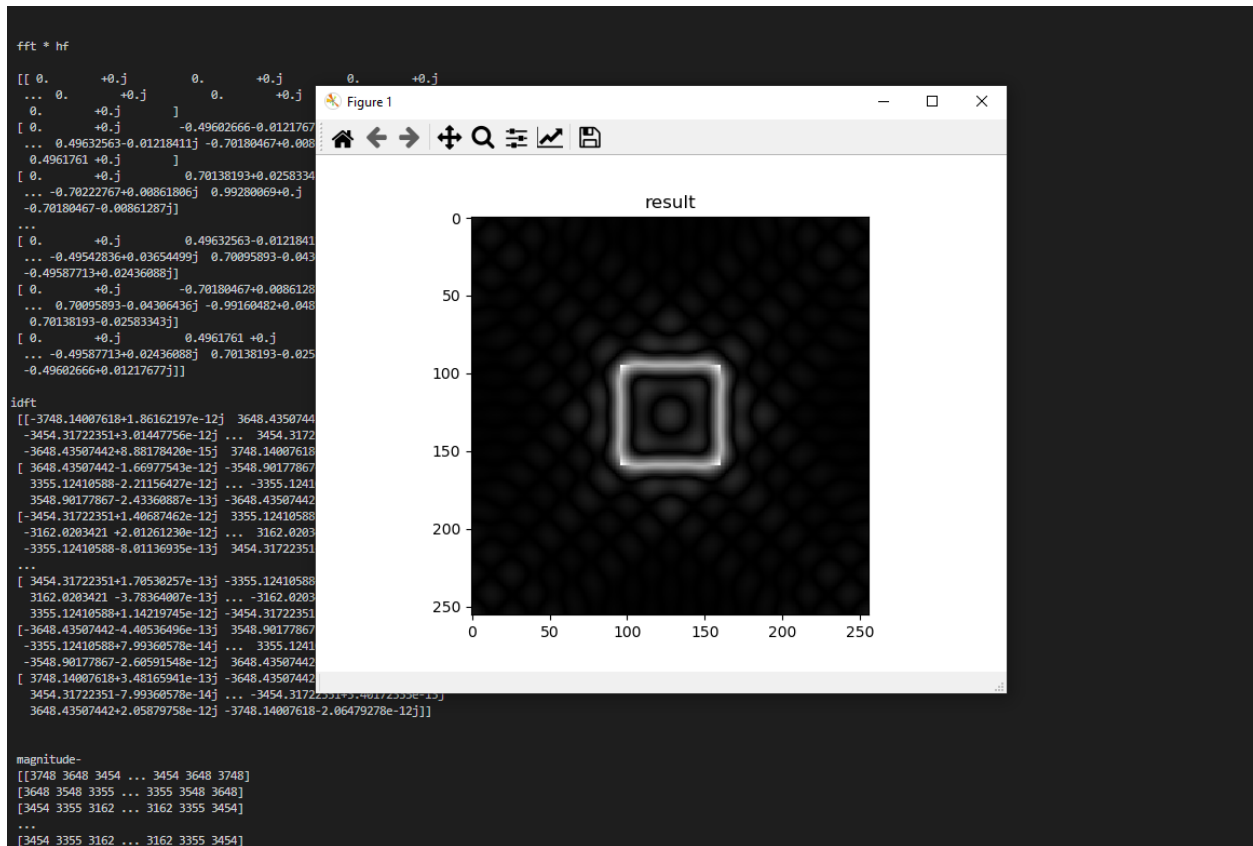


Fig 28- High Pass Filter inverse fft result for the square with the cut off frequency 10

## High Pass filter for the square with the cut off frequency 60

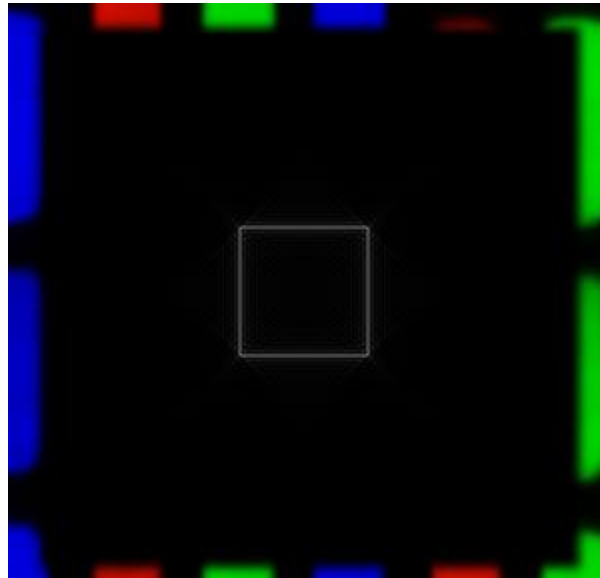


Fig 29 -High Pass filter for the square with the cut off frequency 60

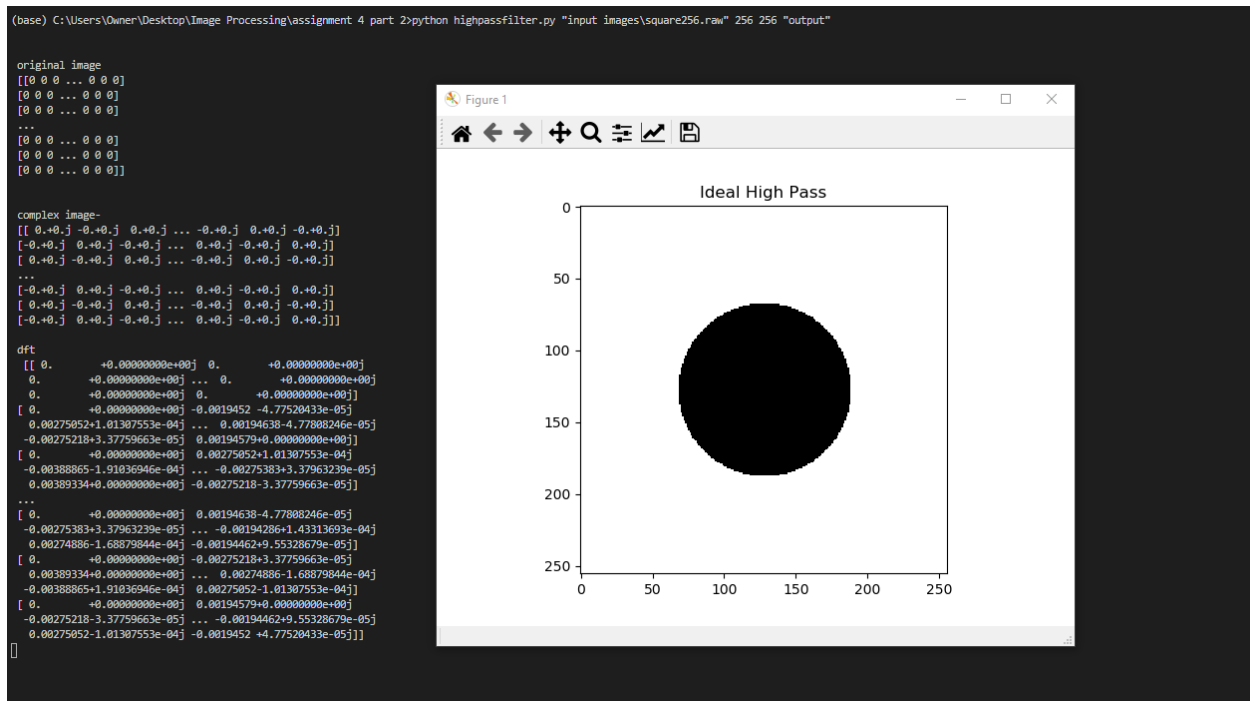


Fig 30- High Pass Filter for the square with the cut off frequency 60

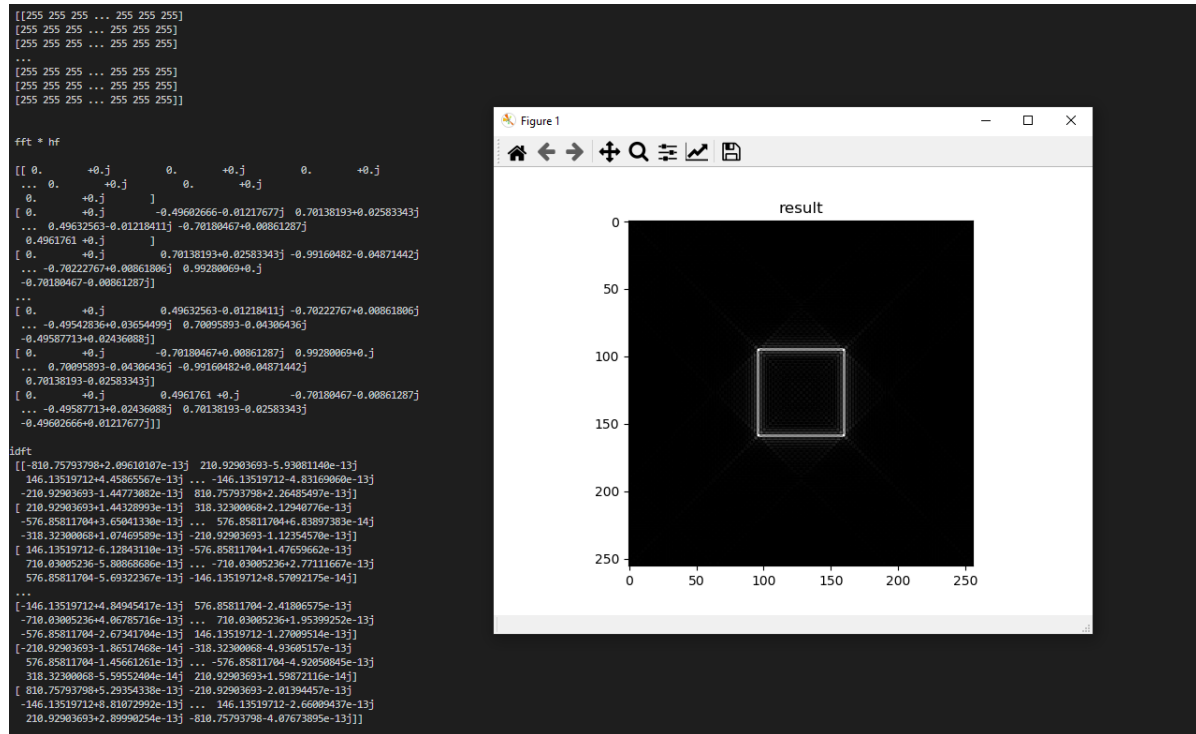


Fig 31- High Pass Filter inverse fft result for the square with the cut off frequency 60