Project

Zhanhao Zhang

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Load Data

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --

## v ggplot2 3.3.3     v purrr   0.3.4
## v tibble  3.0.6     v dplyr   1.0.4
## v tidyr   1.1.2     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.1

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
data <- read.csv("../Data/Runtime.csv")
data
```

```
##          Runtime Processor MatrixSize MatrixOperation Trial
## 1   3.411770e-03       CPU         10        Addition     1
## 2   6.412983e-03       CPU         10        Addition     2
## 3   3.450394e-03       CPU         10        Addition     3
## 4   3.098965e-03       CPU         10        Addition     4
## 5   2.490997e-03       CPU         10        Addition     5
## 6   2.594948e-03       CPU         20        Addition     1
## 7   2.218962e-03       CPU         20        Addition     2
## 8   2.200365e-03       CPU         20        Addition     3
## 9   2.383232e-03       CPU         20        Addition     4
## 10  2.140999e-03       CPU         20        Addition     5
## 11  2.386570e-03       CPU         40        Addition     1
## 12  2.449512e-03       CPU         40        Addition     2
## 13  2.359390e-03       CPU         40        Addition     3
## 14  2.714396e-03       CPU         40        Addition     4
## 15  2.670765e-03       CPU         40        Addition     5
## 16  3.303528e-03       CPU         80        Addition     1
## 17  3.230810e-03       CPU         80        Addition     2
## 18  3.203392e-03       CPU         80        Addition     3
## 19  3.126860e-03       CPU         80        Addition     4
## 20  3.218889e-03       CPU         80        Addition     5
```

```
## 21  6.022930e-03       CPU        160        Addition     1
## 22  5.866289e-03       CPU        160        Addition     2
## 23  5.935192e-03       CPU        160        Addition     3
## 24  5.800247e-03       CPU        160        Addition     4
## 25  5.763054e-03       CPU        160        Addition     5
## 26  6.832409e-02       CPU        320        Addition     1
## 27  7.064033e-02       CPU        320        Addition     2
## 28  6.945658e-02       CPU        320        Addition     3
## 29  6.450629e-02       CPU        320        Addition     4
## 30  6.643939e-02       CPU        320        Addition     5
## 31  2.853811e-01       CPU        640        Addition     1
## 32  2.902746e-01       CPU        640        Addition     2
## 33  2.748492e-01       CPU        640        Addition     3
## 34  2.795281e-01       CPU        640        Addition     4
## 35  2.816803e-01       CPU        640        Addition     5
## 36  1.506005e+00       CPU       1280        Addition     1
## 37  1.511166e+00       CPU       1280        Addition     2
## 38  1.488344e+00       CPU       1280        Addition     3
## 39  1.514571e+00       CPU       1280        Addition     4
## 40  1.502827e+00       CPU       1280        Addition     5
## 41  7.100827e+00       CPU       2560        Addition     1
## 42  7.014891e+00       CPU       2560        Addition     2
## 43  7.013434e+00       CPU       2560        Addition     3
## 44  6.992982e+00       CPU       2560        Addition     4
## 45  7.059267e+00       CPU       2560        Addition     5
## 46  5.617142e-03       CPU         10  Multiplication     1
## 47  3.096581e-03       CPU         10  Multiplication     2
## 48  3.033638e-03       CPU         10  Multiplication     3
## 49  3.046989e-03       CPU         10  Multiplication     4
## 50  3.043890e-03       CPU         10  Multiplication     5
## 51  3.424406e-03       CPU         20  Multiplication     1
## 52  3.337622e-03       CPU         20  Multiplication     2
## 53  3.774405e-03       CPU         20  Multiplication     3
## 54  3.392458e-03       CPU         20  Multiplication     4
## 55  3.380299e-03       CPU         20  Multiplication     5
## 56  4.945993e-03       CPU         40  Multiplication     1
## 57  4.929781e-03       CPU         40  Multiplication     2
## 58  5.309582e-03       CPU         40  Multiplication     3
## 59  4.963636e-03       CPU         40  Multiplication     4
## 60  4.901171e-03       CPU         40  Multiplication     5
## 61  1.993823e-02       CPU         80  Multiplication     1
## 62  2.022171e-02       CPU         80  Multiplication     2
## 63  2.386832e-02       CPU         80  Multiplication     3
## 64  2.033520e-02       CPU         80  Multiplication     4
## 65  1.997018e-02       CPU         80  Multiplication     5
## 66  1.247215e-01       CPU        160  Multiplication     1
## 67  1.356981e-01       CPU        160  Multiplication     2
## 68  1.332617e-01       CPU        160  Multiplication     3
## 69  1.299458e-01       CPU        160  Multiplication     4
## 70  1.263359e-01       CPU        160  Multiplication     5
## 71  1.292714e+00       CPU        320  Multiplication     1
## 72  1.311250e+00       CPU        320  Multiplication     2
## 73  1.316441e+00       CPU        320  Multiplication     3
## 74  1.276813e+00       CPU        320  Multiplication     4
```

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## 75  1.316418e+00       CPU        320  Multiplication     5
## 76  7.708442e+00       CPU        640  Multiplication     1
## 77  7.677559e+00       CPU        640  Multiplication     2
## 78  7.627517e+00       CPU        640  Multiplication     3
## 79  7.670943e+00       CPU        640  Multiplication     4
## 80  7.582686e+00       CPU        640  Multiplication     5
## 81  5.770625e+01       CPU       1280  Multiplication     1
## 82  5.762581e+01       CPU       1280  Multiplication     2
## 83  5.747905e+01       CPU       1280  Multiplication     3
## 84  5.766293e+01       CPU       1280  Multiplication     4
## 85  5.763211e+01       CPU       1280  Multiplication     5
## 86  4.456302e+02       CPU       2560  Multiplication     1
## 87  4.447216e+02       CPU       2560  Multiplication     2
## 88  4.443416e+02       CPU       2560  Multiplication     3
## 89  4.437048e+02       CPU       2560  Multiplication     4
## 90  4.443912e+02       CPU       2560  Multiplication     5
## 91  5.721498e-02       CPU         10       Invertion     1
## 92  8.264065e-03       CPU         10       Invertion     2
## 93  8.229494e-03       CPU         10       Invertion     3
## 94  8.220911e-03       CPU         10       Invertion     4
## 95  8.282900e-03       CPU         10       Invertion     5
## 96  6.422996e-02       CPU         20       Invertion     1
## 97  2.064967e-02       CPU         20       Invertion     2
## 98  1.941037e-02       CPU         20       Invertion     3
## 99  1.921606e-02       CPU         20       Invertion     4
## 100 1.893592e-02       CPU         20       Invertion     5
## 101 4.079461e-02       CPU         40       Invertion     1
## 102 3.970385e-02       CPU         40       Invertion     2
## 103 3.573465e-02       CPU         40       Invertion     3
## 104 3.620172e-02       CPU         40       Invertion     4
## 105 3.874135e-02       CPU         40       Invertion     5
## 106 1.018374e-01       CPU         80       Invertion     1
## 107 1.142936e-01       CPU         80       Invertion     2
## 108 9.712601e-02       CPU         80       Invertion     3
## 109 9.642458e-02       CPU         80       Invertion     4
## 110 9.500837e-02       CPU         80       Invertion     5
## 111 3.467877e-01       CPU        160       Invertion     1
## 112 3.541155e-01       CPU        160       Invertion     2
## 113 3.498223e-01       CPU        160       Invertion     3
## 114 3.508465e-01       CPU        160       Invertion     4
## 115 3.502469e-01       CPU        160       Invertion     5
## 116 1.706526e+00       CPU        320       Invertion     1
## 117 1.716267e+00       CPU        320       Invertion     2
## 118 1.720012e+00       CPU        320       Invertion     3
## 119 1.727209e+00       CPU        320       Invertion     4
## 120 1.704967e+00       CPU        320       Invertion     5
## 121 1.145174e+01       CPU        640       Invertion     1
## 122 1.145586e+01       CPU        640       Invertion     2
## 123 1.151090e+01       CPU        640       Invertion     3
## 124 1.145875e+01       CPU        640       Invertion     4
## 125 1.146682e+01       CPU        640       Invertion     5
## 126 8.019313e+01       CPU       1280       Invertion     1
## 127 7.981307e+01       CPU       1280       Invertion     2
## 128 7.963684e+01       CPU       1280       Invertion     3
```

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## 129 7.935936e+01       CPU       1280       Invertion     4
## 130 7.939678e+01       CPU       1280       Invertion     5
## 131 5.603823e+02       CPU       2560       Invertion     1
## 132 5.602631e+02       CPU       2560       Invertion     2
## 133 5.618624e+02       CPU       2560       Invertion     3
## 134 5.622823e+02       CPU       2560       Invertion     4
## 135 5.604420e+02       CPU       2560       Invertion     5
## 136 7.737160e-03       GPU         10        Addition     1
## 137 6.760120e-03       GPU         10        Addition     2
## 138 6.684542e-03       GPU         10        Addition     3
## 139 6.717205e-03       GPU         10        Addition     4
## 140 6.702423e-03       GPU         10        Addition     5
## 141 7.873774e-03       GPU         20        Addition     1
## 142 7.232428e-03       GPU         20        Addition     2
## 143 6.582737e-03       GPU         20        Addition     3
## 144 6.649256e-03       GPU         20        Addition     4
## 145 6.689072e-03       GPU         20        Addition     5
## 146 6.715775e-03       GPU         40        Addition     1
## 147 6.691694e-03       GPU         40        Addition     2
## 148 7.096767e-03       GPU         40        Addition     3
## 149 6.767035e-03       GPU         40        Addition     4
## 150 6.821871e-03       GPU         40        Addition     5
## 151 8.438826e-03       GPU         80        Addition     1
## 152 6.768942e-03       GPU         80        Addition     2
## 153 6.777525e-03       GPU         80        Addition     3
## 154 6.748438e-03       GPU         80        Addition     4
## 155 6.622314e-03       GPU         80        Addition     5
## 156 6.753206e-03       GPU        160        Addition     1
## 157 6.635666e-03       GPU        160        Addition     2
## 158 8.101463e-03       GPU        160        Addition     3
## 159 6.666422e-03       GPU        160        Addition     4
## 160 6.638527e-03       GPU        160        Addition     5
## 161 6.897211e-03       GPU        320        Addition     1
## 162 6.696463e-03       GPU        320        Addition     2
## 163 8.470535e-03       GPU        320        Addition     3
## 164 6.931305e-03       GPU        320        Addition     4
## 165 7.388830e-03       GPU        320        Addition     5
## 166 6.553650e-03       GPU        640        Addition     1
## 167 6.502867e-03       GPU        640        Addition     2
## 168 6.640434e-03       GPU        640        Addition     3
## 169 6.725311e-03       GPU        640        Addition     4
## 170 6.741524e-03       GPU        640        Addition     5
## 171 7.200241e-03       GPU       1280        Addition     1
## 172 7.092237e-03       GPU       1280        Addition     2
## 173 1.200223e-02       GPU       1280        Addition     3
## 174 1.145720e-02       GPU       1280        Addition     4
## 175 1.106763e-02       GPU       1280        Addition     5
## 176 6.871223e-03       GPU       2560        Addition     1
## 177 6.925583e-03       GPU       2560        Addition     2
## 178 6.436825e-03       GPU       2560        Addition     3
## 179 6.400108e-03       GPU       2560        Addition     4
## 180 6.696463e-03       GPU       2560        Addition     5
## 181 2.334929e-02       GPU         10  Multiplication     1
## 182 8.390188e-03       GPU         10  Multiplication     2
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## 183 9.738922e-03       GPU         10  Multiplication     3
## 184 1.087260e-02       GPU         10  Multiplication     4
## 185 8.431435e-03       GPU         10  Multiplication     5
## 186 8.605957e-03       GPU         20  Multiplication     1
## 187 8.709908e-03       GPU         20  Multiplication     2
## 188 9.181976e-03       GPU         20  Multiplication     3
## 189 8.762360e-03       GPU         20  Multiplication     4
## 190 8.559465e-03       GPU         20  Multiplication     5
## 191 8.393288e-03       GPU         40  Multiplication     1
## 192 8.482695e-03       GPU         40  Multiplication     2
## 193 8.392334e-03       GPU         40  Multiplication     3
## 194 8.416176e-03       GPU         40  Multiplication     4
## 195 8.292913e-03       GPU         40  Multiplication     5
## 196 9.845257e-03       GPU         80  Multiplication     1
## 197 9.139776e-03       GPU         80  Multiplication     2
## 198 9.043455e-03       GPU         80  Multiplication     3
## 199 8.636713e-03       GPU         80  Multiplication     4
## 200 8.564949e-03       GPU         80  Multiplication     5
## 201 8.630991e-03       GPU        160  Multiplication     1
## 202 8.578777e-03       GPU        160  Multiplication     2
## 203 8.558035e-03       GPU        160  Multiplication     3
## 204 8.576632e-03       GPU        160  Multiplication     4
## 205 8.617163e-03       GPU        160  Multiplication     5
## 206 9.922028e-03       GPU        320  Multiplication     1
## 207 8.571148e-03       GPU        320  Multiplication     2
## 208 9.797335e-03       GPU        320  Multiplication     3
## 209 8.650303e-03       GPU        320  Multiplication     4
## 210 8.684158e-03       GPU        320  Multiplication     5
## 211 5.869818e-02       GPU        640  Multiplication     1
## 212 6.490087e-02       GPU        640  Multiplication     2
## 213 6.519628e-02       GPU        640  Multiplication     3
## 214 6.430983e-02       GPU        640  Multiplication     4
## 215 6.602740e-02       GPU        640  Multiplication     5
## 216 5.413406e-01       GPU       1280  Multiplication     1
## 217 5.302551e-01       GPU       1280  Multiplication     2
## 218 5.325379e-01       GPU       1280  Multiplication     3
## 219 5.381818e-01       GPU       1280  Multiplication     4
## 220 5.477204e-01       GPU       1280  Multiplication     5
## 221 8.498430e-03       GPU       2560  Multiplication     1
## 222 8.300304e-03       GPU       2560  Multiplication     2
## 223 8.370638e-03       GPU       2560  Multiplication     3
## 224 8.469582e-03       GPU       2560  Multiplication     4
## 225 1.376939e-02       GPU       2560  Multiplication     5
## 226 1.310921e-01       GPU         10       Invertion     1
## 227 1.370540e-01       GPU         10       Invertion     2
## 228 1.452184e-01       GPU         10       Invertion     3
## 229 1.475253e-01       GPU         10       Invertion     4
## 230 1.164386e-01       GPU         10       Invertion     5
## 231 1.314116e-01       GPU         20       Invertion     1
## 232 1.389875e-01       GPU         20       Invertion     2
## 233 1.350033e-01       GPU         20       Invertion     3
## 234 1.591120e-01       GPU         20       Invertion     4
## 235 1.613362e-01       GPU         20       Invertion     5
## 236 2.348750e-01       GPU         40       Invertion     1
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## 237 2.170925e-01       GPU         40       Invertion     2
## 238 2.195408e-01       GPU         40       Invertion     3
## 239 2.424490e-01       GPU         40       Invertion     4
## 240 2.506576e-01       GPU         40       Invertion     5
## 241 3.812754e-01       GPU         80       Invertion     1
## 242 3.842969e-01       GPU         80       Invertion     2
## 243 3.821032e-01       GPU         80       Invertion     3
## 244 3.926630e-01       GPU         80       Invertion     4
## 245 4.039948e-01       GPU         80       Invertion     5
## 246 7.055206e-01       GPU        160       Invertion     1
## 247 6.990435e-01       GPU        160       Invertion     2
## 248 6.943610e-01       GPU        160       Invertion     3
## 249 7.024891e-01       GPU        160       Invertion     4
## 250 6.917412e-01       GPU        160       Invertion     5
## 251 1.810985e+00       GPU        320       Invertion     1
## 252 1.820739e+00       GPU        320       Invertion     2
## 253 1.820264e+00       GPU        320       Invertion     3
## 254 1.819141e+00       GPU        320       Invertion     4
## 255 1.830150e+00       GPU        320       Invertion     5
## 256 4.449073e+00       GPU        640       Invertion     1
## 257 4.447138e+00       GPU        640       Invertion     2
## 258 4.456288e+00       GPU        640       Invertion     3
## 259 4.468697e+00       GPU        640       Invertion     4
## 260 4.437547e+00       GPU        640       Invertion     5
## 261 1.154401e+01       GPU       1280       Invertion     1
## 262 1.154629e+01       GPU       1280       Invertion     2
## 263 1.147941e+01       GPU       1280       Invertion     3
## 264 1.145188e+01       GPU       1280       Invertion     4
## 265 1.145984e+01       GPU       1280       Invertion     5
## 266 4.176211e+01       GPU       2560       Invertion     1
## 267 4.183814e+01       GPU       2560       Invertion     2
## 268 4.178711e+01       GPU       2560       Invertion     3
## 269 4.185825e+01       GPU       2560       Invertion     4
## 270 4.181421e+01       GPU       2560       Invertion     5
## 271 4.732847e-03       TPU         10        Addition     1
## 272 6.595850e-03       TPU         10        Addition     2
## 273 4.762411e-03       TPU         10        Addition     3
## 274 4.580259e-03       TPU         10        Addition     4
## 275 4.661798e-03       TPU         10        Addition     5
## 276 4.890203e-03       TPU         20        Addition     1
## 277 4.884481e-03       TPU         20        Addition     2
## 278 4.809618e-03       TPU         20        Addition     3
## 279 4.830837e-03       TPU         20        Addition     4
## 280 6.026745e-03       TPU         20        Addition     5
## 281 4.893541e-03       TPU         40        Addition     1
## 282 7.666111e-03       TPU         40        Addition     2
## 283 6.231308e-03       TPU         40        Addition     3
## 284 4.955530e-03       TPU         40        Addition     4
## 285 5.219460e-03       TPU         40        Addition     5
## 286 9.574413e-03       TPU         80        Addition     1
## 287 6.096601e-03       TPU         80        Addition     2
## 288 4.938126e-03       TPU         80        Addition     3
## 289 5.182743e-03       TPU         80        Addition     4
## 290 4.791021e-03       TPU         80        Addition     5
```

```
## 291 4.870176e-03       TPU        160        Addition     1
## 292 4.971027e-03       TPU        160        Addition     2
## 293 7.506371e-03       TPU        160        Addition     3
## 294 5.704403e-03       TPU        160        Addition     4
## 295 5.309105e-03       TPU        160        Addition     5
## 296 4.802465e-03       TPU        320        Addition     1
## 297 4.835129e-03       TPU        320        Addition     2
## 298 4.721403e-03       TPU        320        Addition     3
## 299 4.740477e-03       TPU        320        Addition     4
## 300 5.425930e-03       TPU        320        Addition     5
## 301 4.768372e-03       TPU        640        Addition     1
## 302 4.792452e-03       TPU        640        Addition     2
## 303 4.734516e-03       TPU        640        Addition     3
## 304 5.617380e-03       TPU        640        Addition     4
## 305 4.827738e-03       TPU        640        Addition     5
## 306 4.825830e-03       TPU       1280        Addition     1
## 307 8.559704e-03       TPU       1280        Addition     2
## 308 9.112597e-03       TPU       1280        Addition     3
## 309 6.001472e-03       TPU       1280        Addition     4
## 310 4.752398e-03       TPU       1280        Addition     5
## 311 4.836082e-03       TPU       2560        Addition     1
## 312 4.759550e-03       TPU       2560        Addition     2
## 313 4.689932e-03       TPU       2560        Addition     3
## 314 4.836559e-03       TPU       2560        Addition     4
## 315 4.698753e-03       TPU       2560        Addition     5
## 316 3.074169e-03       TPU         10  Multiplication     1
## 317 4.003048e-03       TPU         10  Multiplication     2
## 318 2.987862e-03       TPU         10  Multiplication     3
## 319 3.744841e-03       TPU         10  Multiplication     4
## 320 2.981901e-03       TPU         10  Multiplication     5
## 321 2.958298e-03       TPU         20  Multiplication     1
## 322 2.847195e-03       TPU         20  Multiplication     2
## 323 2.870321e-03       TPU         20  Multiplication     3
## 324 2.861977e-03       TPU         20  Multiplication     4
## 325 2.814054e-03       TPU         20  Multiplication     5
## 326 2.965212e-03       TPU         40  Multiplication     1
## 327 2.985716e-03       TPU         40  Multiplication     2
## 328 2.880812e-03       TPU         40  Multiplication     3
## 329 2.977133e-03       TPU         40  Multiplication     4
## 330 3.998995e-03       TPU         40  Multiplication     5
## 331 4.498005e-03       TPU         80  Multiplication     1
## 332 4.730225e-03       TPU         80  Multiplication     2
## 333 3.031254e-03       TPU         80  Multiplication     3
## 334 5.091906e-03       TPU         80  Multiplication     4
## 335 2.954960e-03       TPU         80  Multiplication     5
## 336 3.142595e-03       TPU        160  Multiplication     1
## 337 2.988815e-03       TPU        160  Multiplication     2
## 338 2.924681e-03       TPU        160  Multiplication     3
## 339 2.961636e-03       TPU        160  Multiplication     4
## 340 2.952814e-03       TPU        160  Multiplication     5
## 341 2.974749e-03       TPU        320  Multiplication     1
## 342 2.890587e-03       TPU        320  Multiplication     2
## 343 2.942562e-03       TPU        320  Multiplication     3
## 344 2.915621e-03       TPU        320  Multiplication     4
```

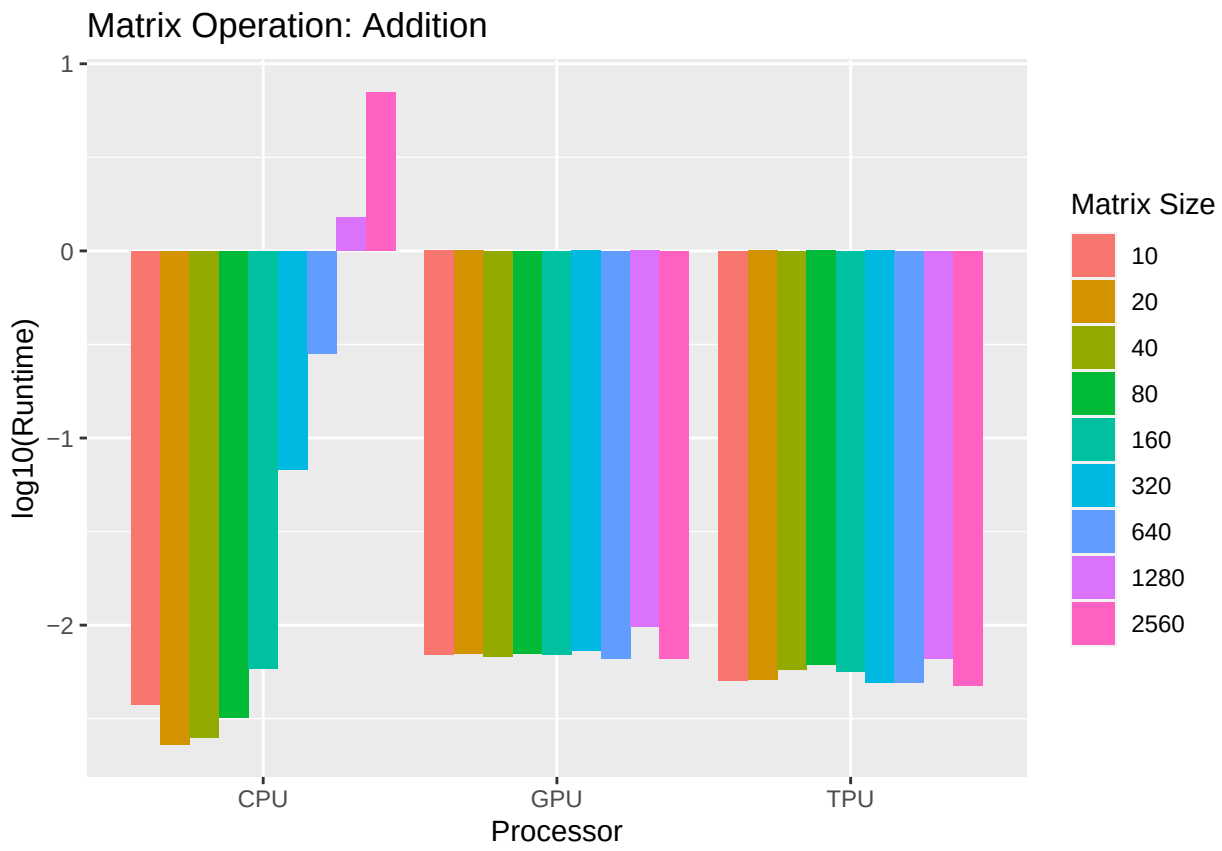
```
## 345 2.899885e-03       TPU        320  Multiplication     5
## 346 2.943516e-03       TPU        640  Multiplication     1
## 347 2.967358e-03       TPU        640  Multiplication     2
## 348 2.979517e-03       TPU        640  Multiplication     3
## 349 2.977848e-03       TPU        640  Multiplication     4
## 350 2.951622e-03       TPU        640  Multiplication     5
## 351 3.038645e-03       TPU       1280  Multiplication     1
## 352 5.813122e-03       TPU       1280  Multiplication     2
## 353 2.966404e-03       TPU       1280  Multiplication     3
## 354 2.988815e-03       TPU       1280  Multiplication     4
## 355 3.012896e-03       TPU       1280  Multiplication     5
## 356 2.970457e-03       TPU       2560  Multiplication     1
## 357 2.898932e-03       TPU       2560  Multiplication     2
## 358 3.026962e-03       TPU       2560  Multiplication     3
## 359 3.009558e-03       TPU       2560  Multiplication     4
## 360 2.920389e-03       TPU       2560  Multiplication     5
## 361 2.037525e-03       TPU         10       Invertion     1
## 362 1.943827e-03       TPU         10       Invertion     2
## 363 3.208876e-03       TPU         10       Invertion     3
## 364 1.893044e-03       TPU         10       Invertion     4
## 365 1.941919e-03       TPU         10       Invertion     5
## 366 4.729986e-03       TPU         20       Invertion     1
## 367 2.047300e-03       TPU         20       Invertion     2
## 368 1.972675e-03       TPU         20       Invertion     3
## 369 1.916409e-03       TPU         20       Invertion     4
## 370 2.035141e-03       TPU         20       Invertion     5
## 371 1.996517e-03       TPU         40       Invertion     1
## 372 1.935244e-03       TPU         40       Invertion     2
## 373 1.902819e-03       TPU         40       Invertion     3
## 374 1.906872e-03       TPU         40       Invertion     4
## 375 1.927376e-03       TPU         40       Invertion     5
## 376 1.966238e-03       TPU         80       Invertion     1
## 377 1.910210e-03       TPU         80       Invertion     2
## 378 1.912594e-03       TPU         80       Invertion     3
## 379 1.947403e-03       TPU         80       Invertion     4
## 380 1.913309e-03       TPU         80       Invertion     5
## 381 1.887560e-03       TPU        160       Invertion     1
## 382 1.967907e-03       TPU        160       Invertion     2
## 383 1.948118e-03       TPU        160       Invertion     3
## 384 1.870394e-03       TPU        160       Invertion     4
## 385 1.882315e-03       TPU        160       Invertion     5
## 386 1.933098e-03       TPU        320       Invertion     1
## 387 2.880573e-03       TPU        320       Invertion     2
## 388 1.991272e-03       TPU        320       Invertion     3
## 389 2.052307e-03       TPU        320       Invertion     4
## 390 2.048254e-03       TPU        320       Invertion     5
## 391 2.006531e-03       TPU        640       Invertion     1
## 392 1.998663e-03       TPU        640       Invertion     2
## 393 2.048731e-03       TPU        640       Invertion     3
## 394 1.973391e-03       TPU        640       Invertion     4
## 395 1.965523e-03       TPU        640       Invertion     5
## 396 1.962900e-03       TPU       1280       Invertion     1
## 397 1.963615e-03       TPU       1280       Invertion     2
## 398 2.020121e-03       TPU       1280       Invertion     3
```

```
## 399 1.993179e-03       TPU       1280       Invertion     4
## 400 1.967430e-03       TPU       1280       Invertion     5
## 401 1.981497e-03       TPU       2560       Invertion     1
## 402 1.975775e-03       TPU       2560       Invertion     2
## 403 4.290581e-03       TPU       2560       Invertion     3
## 404 1.977205e-03       TPU       2560       Invertion     4
## 405 1.984119e-03       TPU       2560       Invertion     5
```

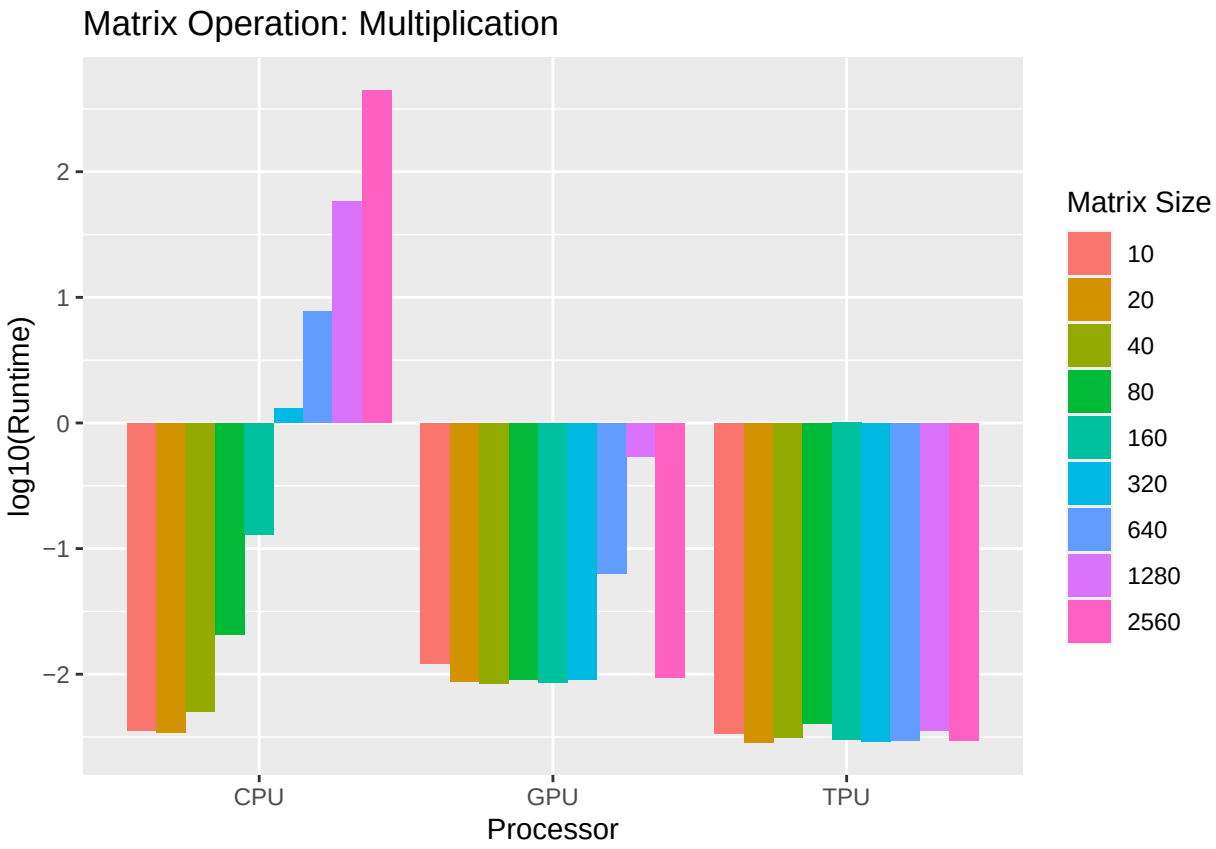
Interaction Plots

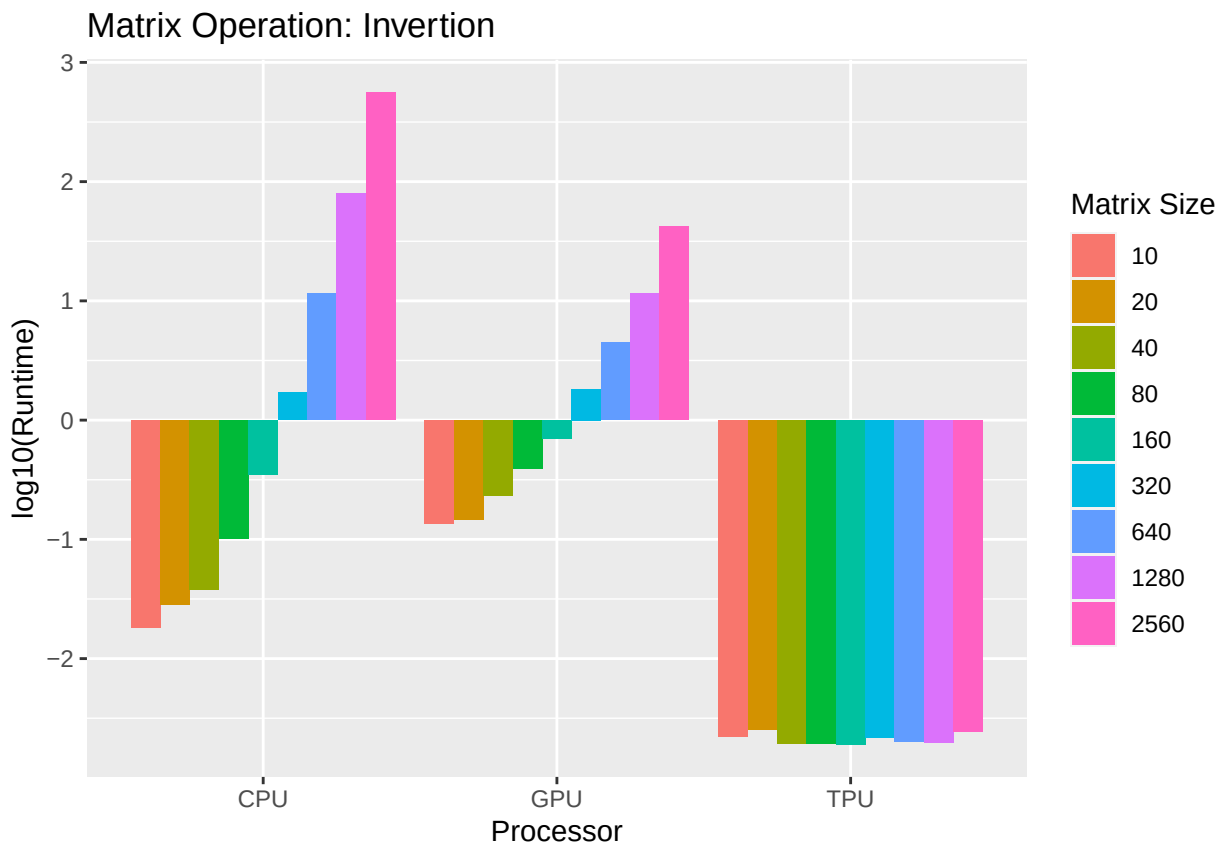
```
#ggplot(data = data, aes(x = Processor, y = log10(Runtime))) +
 # geom_boxplot(aes(fill = MatrixOperation))
for(operation in unique(data$MatrixOperation)){
  p <- data %>%
    filter(MatrixOperation == operation, MatrixSize <= 2560) %>%
    group_by(MatrixSize, MatrixOperation, Processor) %>%
    summarize(Runtime = mean(Runtime)) %>%
    ggplot(aes(x = Processor, y = log10(Runtime))) +
    #geom_boxplot(aes(fill = as.factor(MatrixSize))) +
    geom_bar(aes(fill = as.factor(MatrixSize)), stat = "identity",
             position = "dodge") +
    ggtitle(paste0("Matrix Operation: ", operation)) +
    #facet_wrap( ~ MatrixOperation, scales = "free", nrow = 1) +
    guides(fill=guide_legend(title = "Matrix Size"))
  print(p)
}
```

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



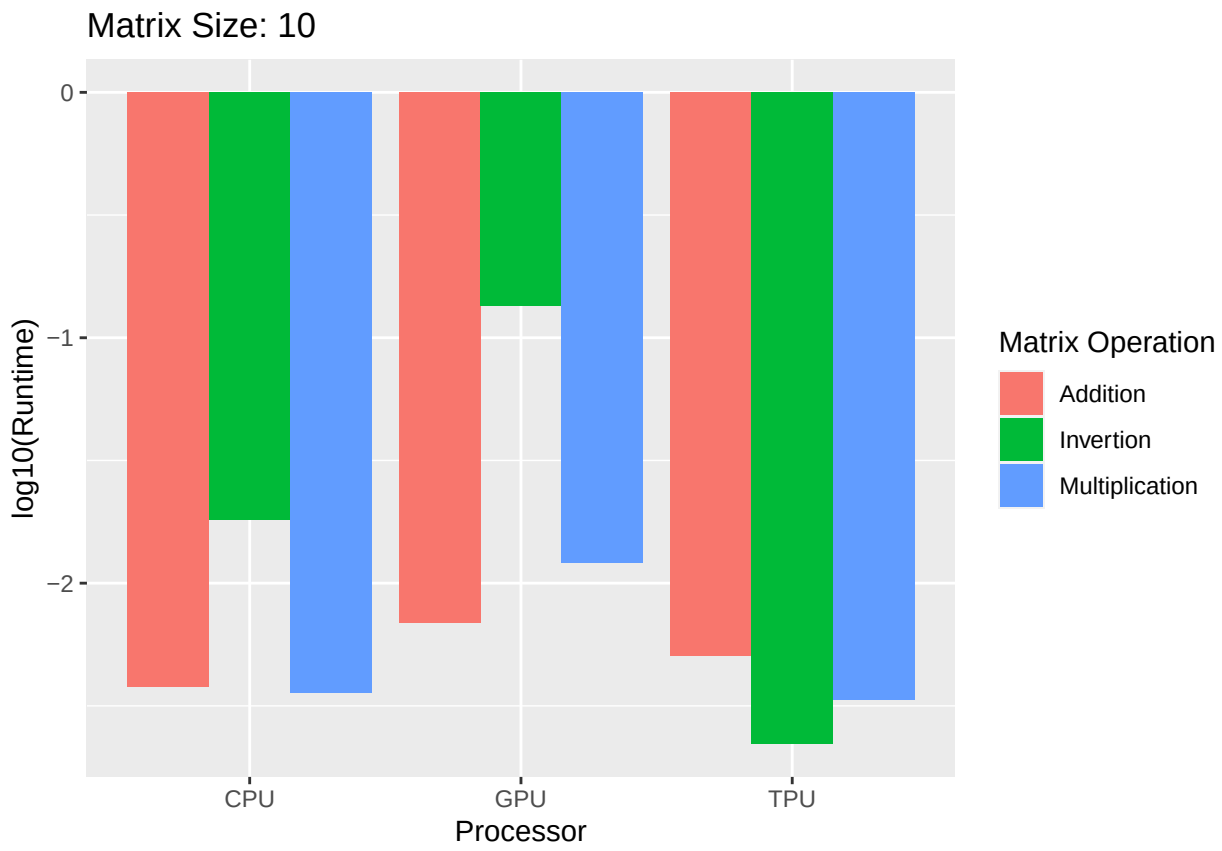

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```


Matrix Operation: Multiplication
log10(Runtime)
2
1
0
−1
−2
CPU
GPU
TPU
Processor
Matrix Size
10
20
40
80
160
320
640
1280
2560

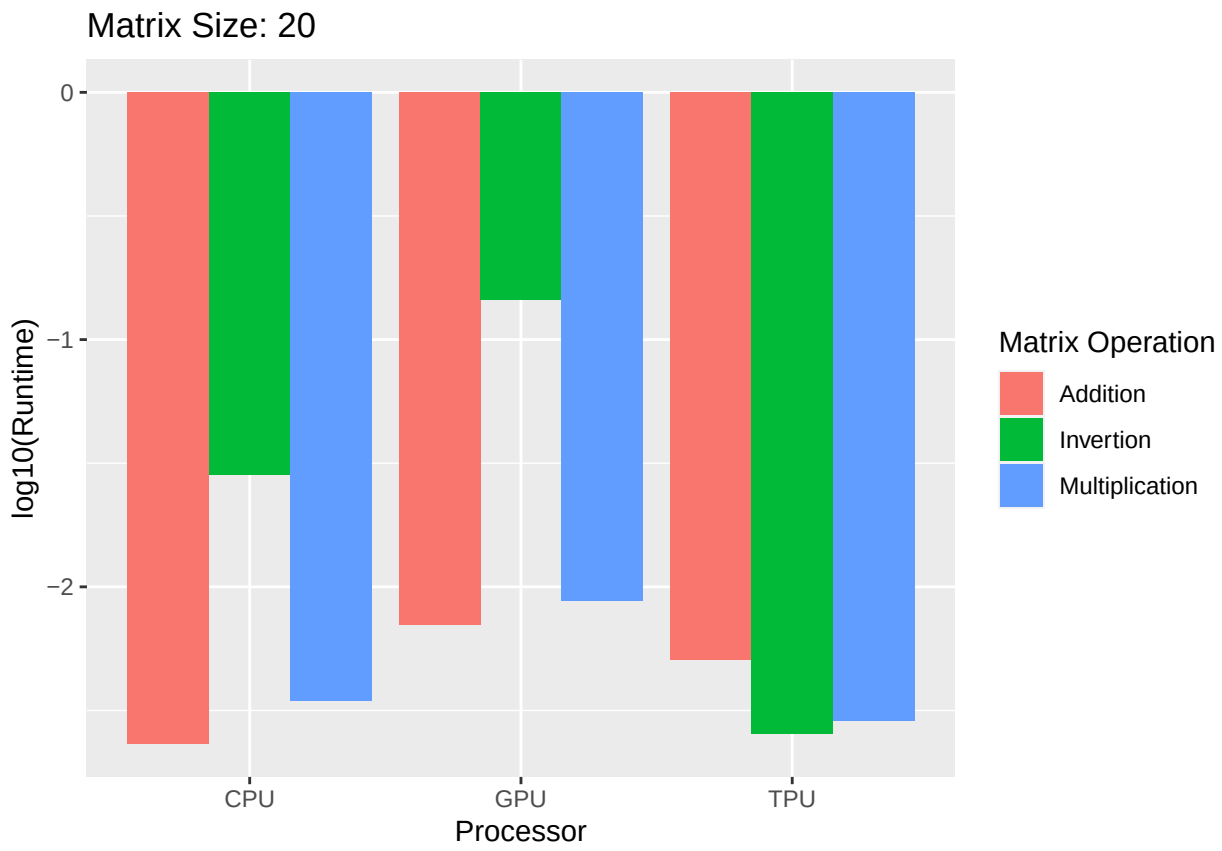



```
for(size in unique(data$MatrixSize)){
  p <- data %>%
    filter(MatrixSize == size) %>%
    group_by(MatrixSize, MatrixOperation, Processor) %>%
    summarize(Runtime = mean(Runtime)) %>%
    ggplot(aes(x = Processor, y = log10(Runtime))) +
    #geom_boxplot(aes(fill = as.factor(MatrixOperation))) +
    geom_bar(aes(fill = as.factor(MatrixOperation)), position = "dodge",
             stat = "identity") +
    ggtitle(paste0("Matrix Size: ", size)) +
    #facet_wrap( ~ MatrixOperation, scales = "free", nrow = 1) +
    guides(fill=guide_legend(title = "Matrix Operation"))
  print(p)
}
```

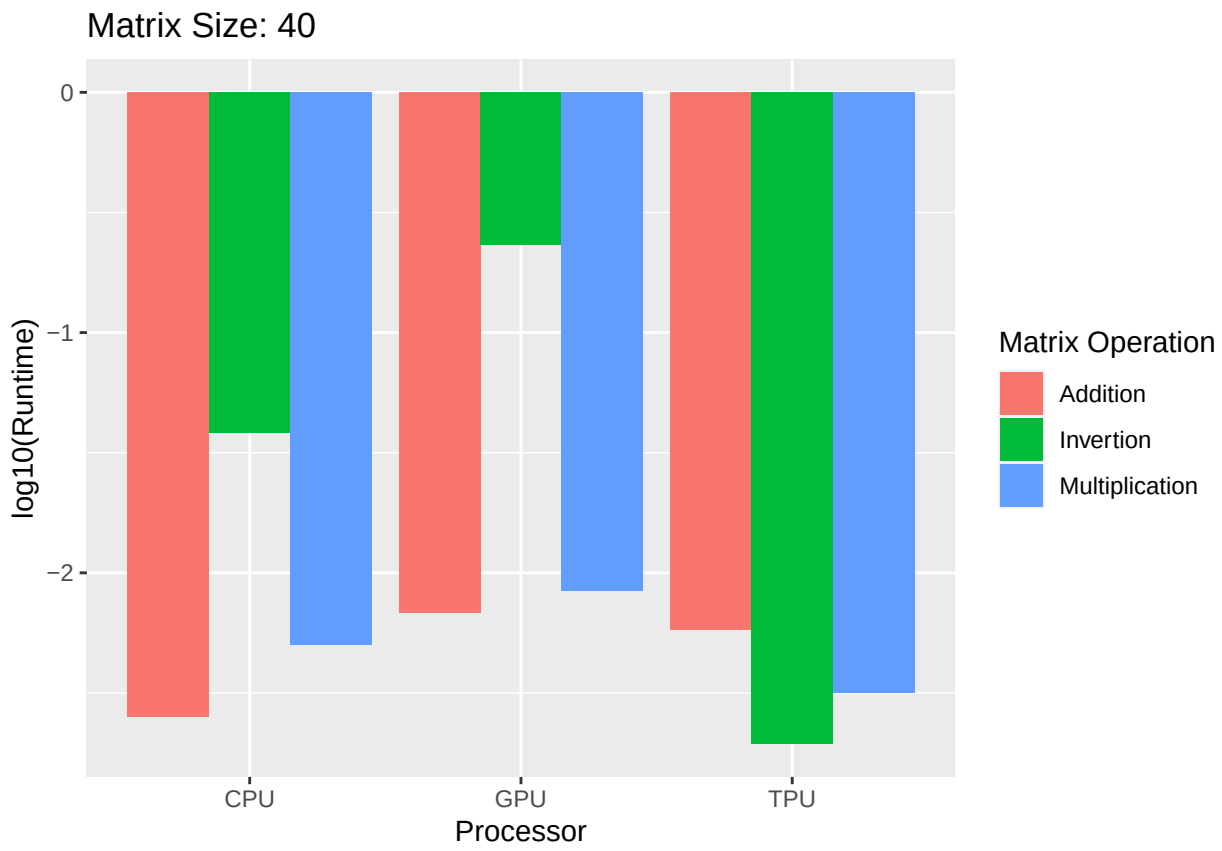
```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



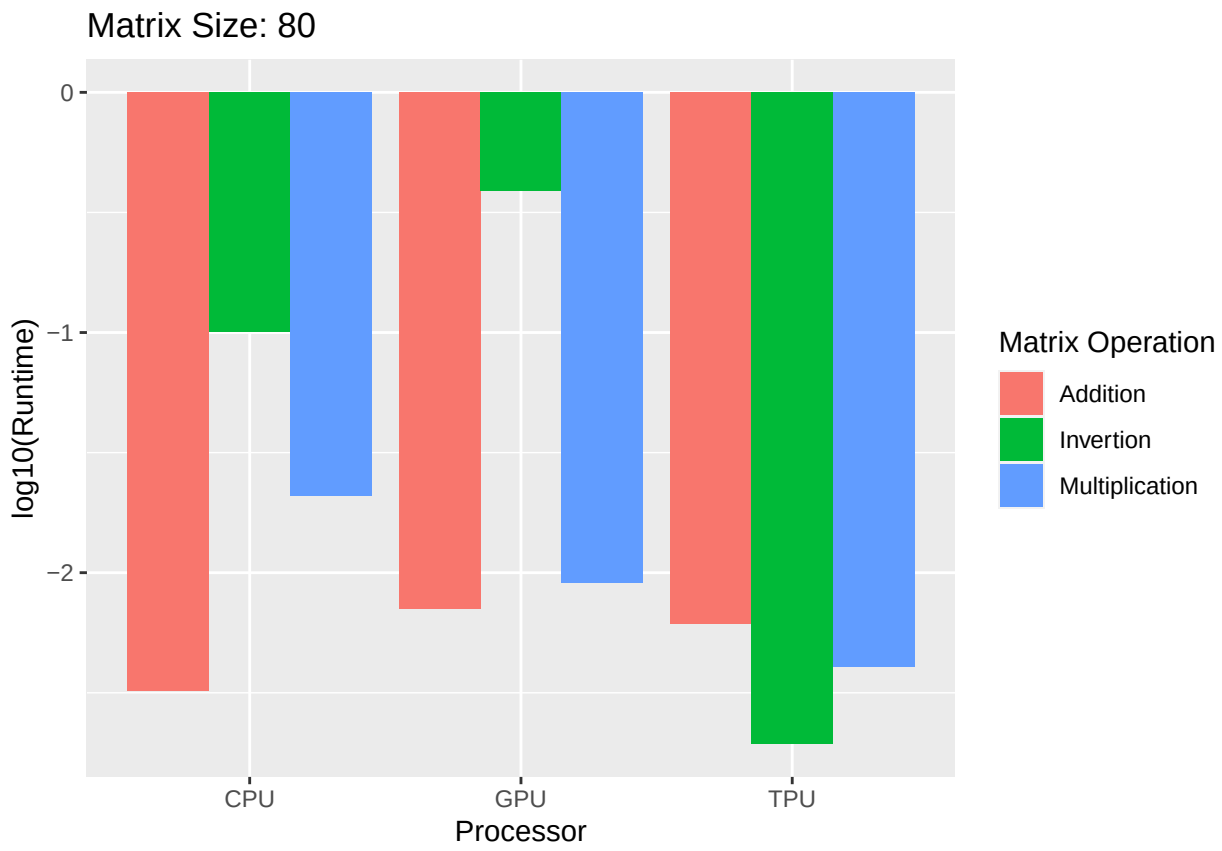

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



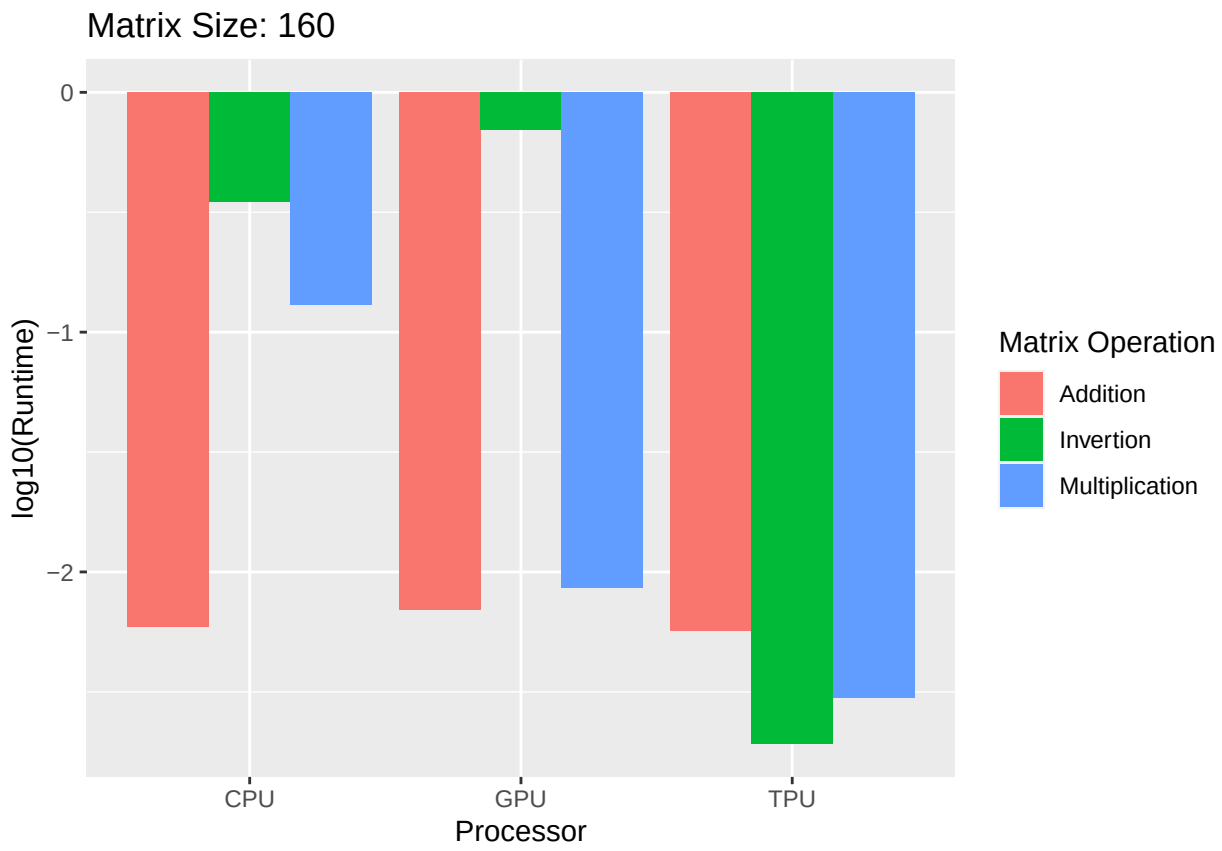

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



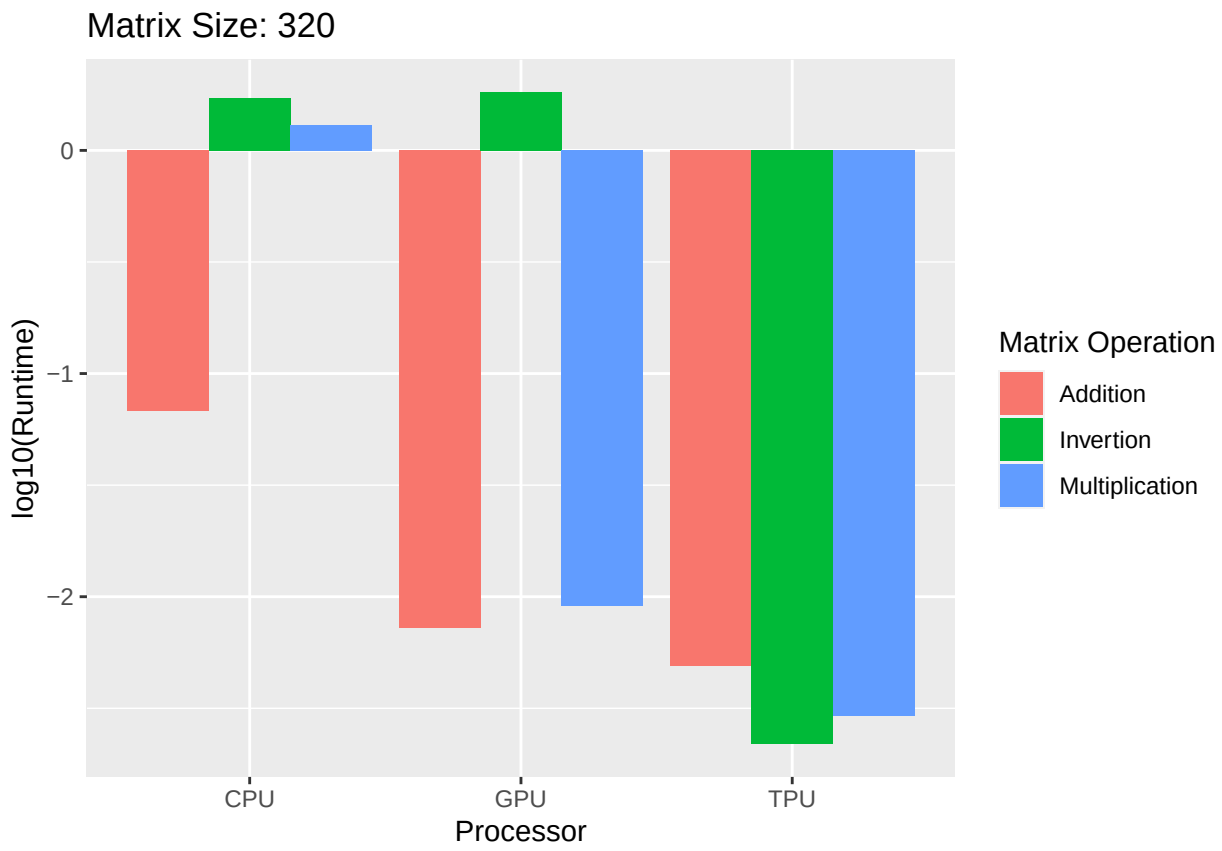

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```




```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```

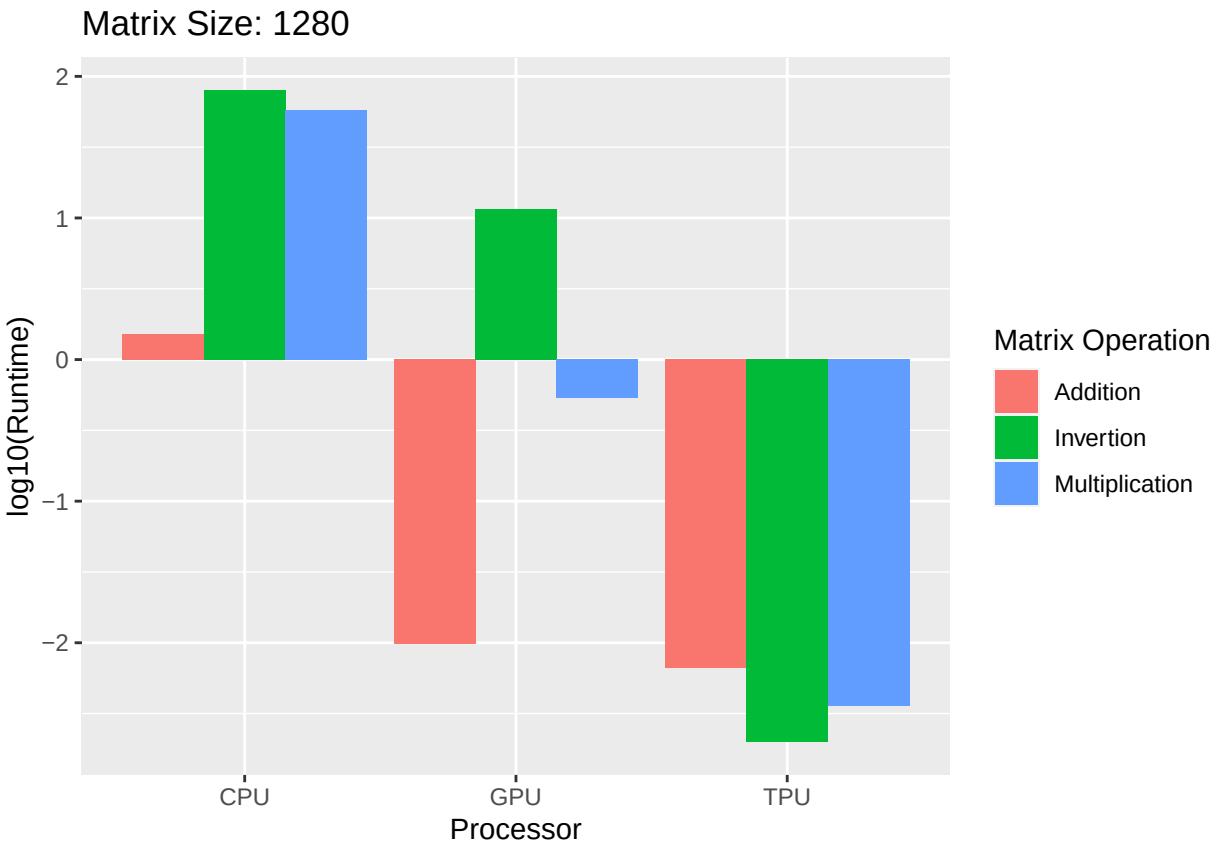


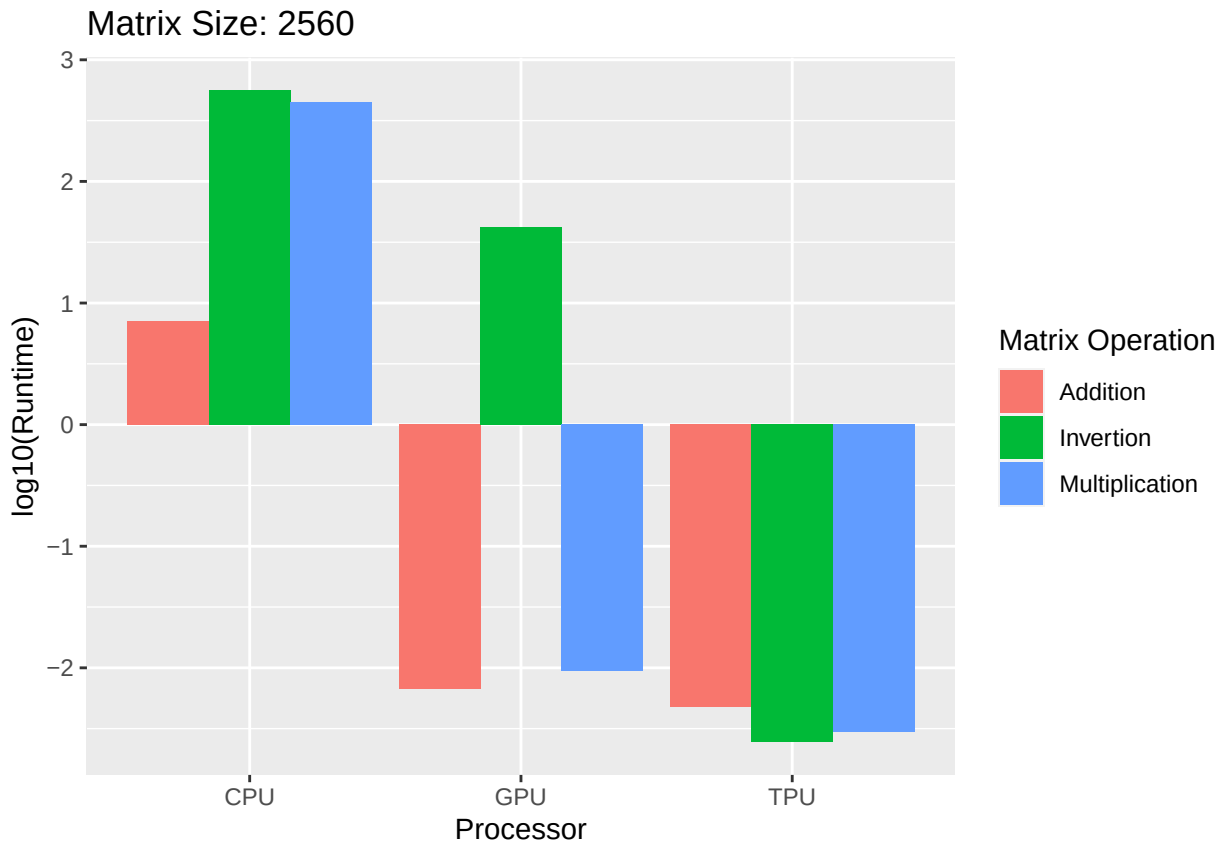

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```




```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```

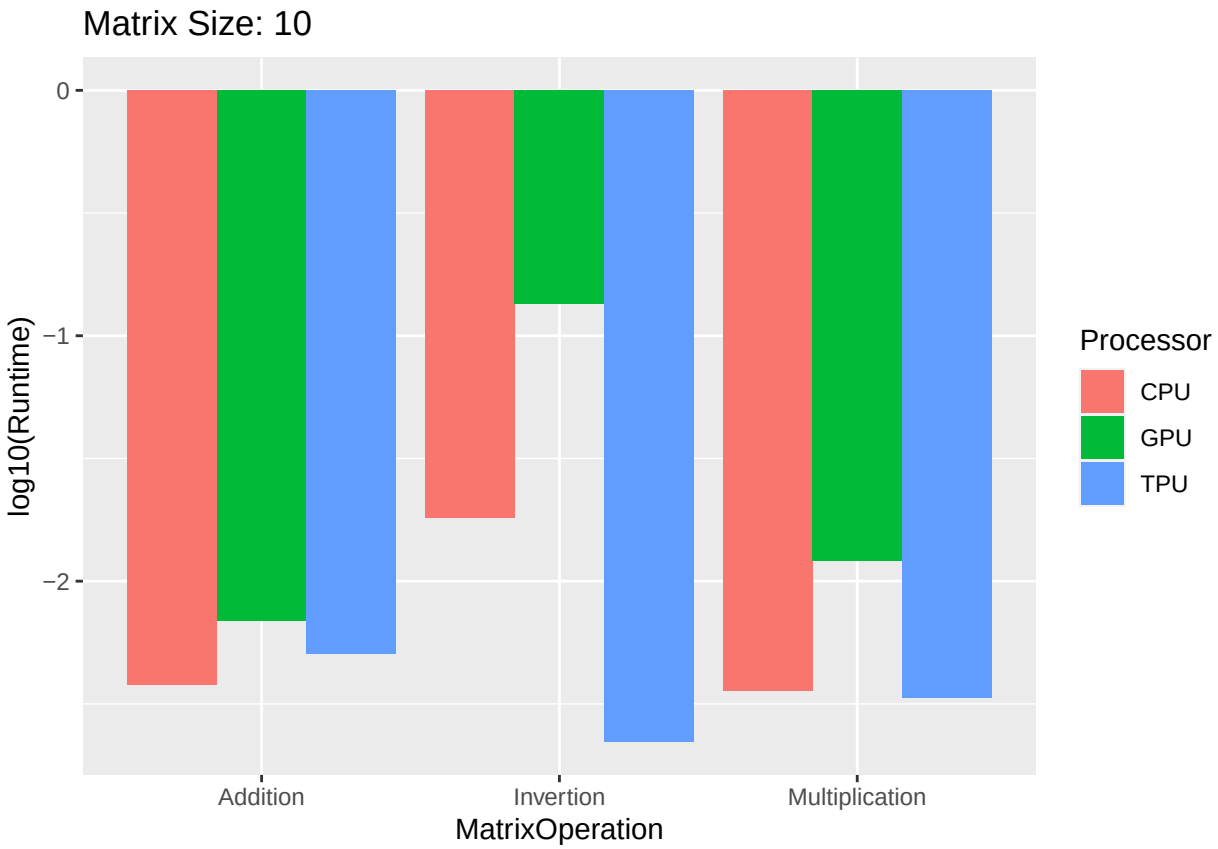

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```


Matrix Size: 1280
log10(Runtime)
2
1
0
−1
−2
CPU
GPU
TPU
Processor
Matrix Operation
Addition
Invertion
Multiplication

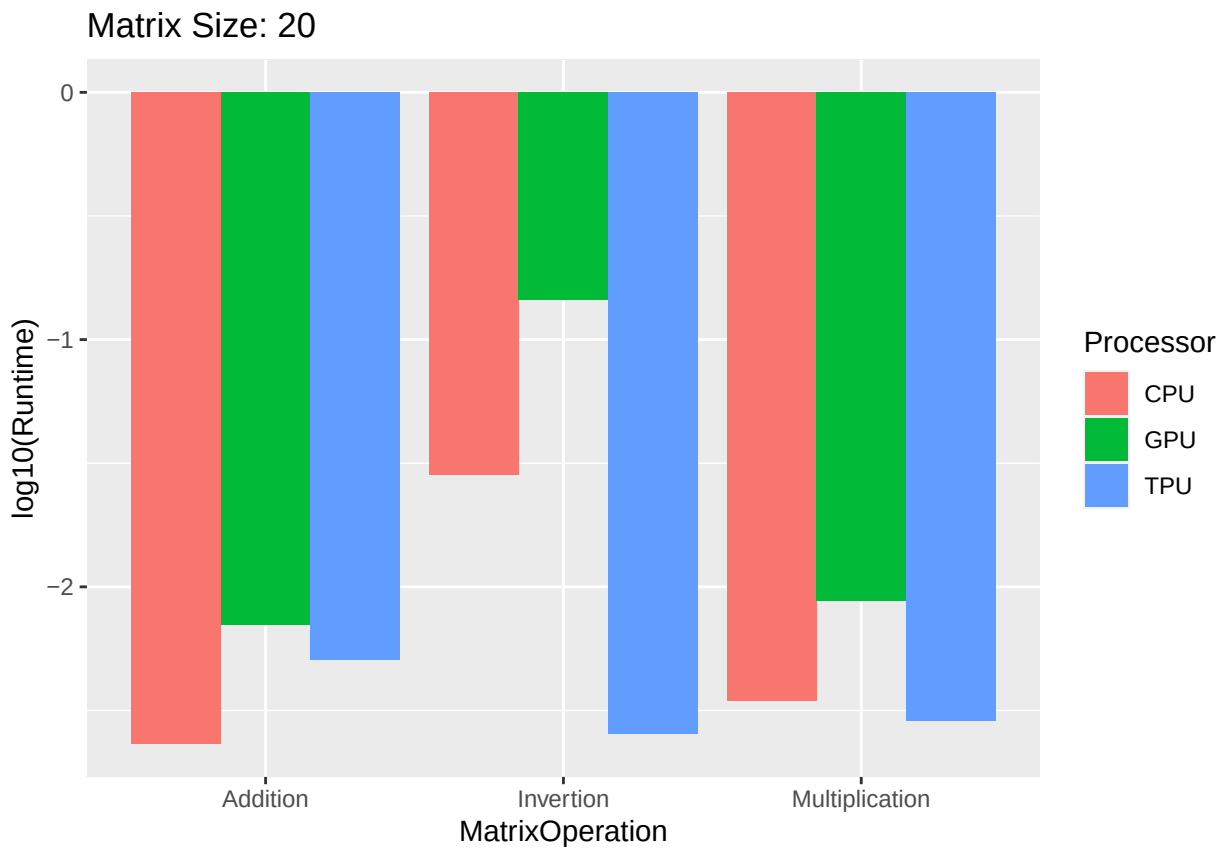



```
for(size in unique(data$MatrixSize)){
  p <- data %>%
    filter(MatrixSize == size) %>%
    group_by(MatrixSize, MatrixOperation, Processor) %>%
    summarize(Runtime = mean(Runtime)) %>%
    ggplot(aes(x = MatrixOperation, y = log10(Runtime))) +
    #geom_boxplot(aes(fill = as.factor(Processor))) +
    geom_bar(aes(fill = as.factor(Processor)), position = "dodge",
             stat = "identity") +
    ggtitle(paste0("Matrix Size: ", size)) +
    #facet_wrap( ~ MatrixOperation, scales = "free", nrow = 1) +
    guides(fill=guide_legend(title = "Processor"))
  print(p)
}
```

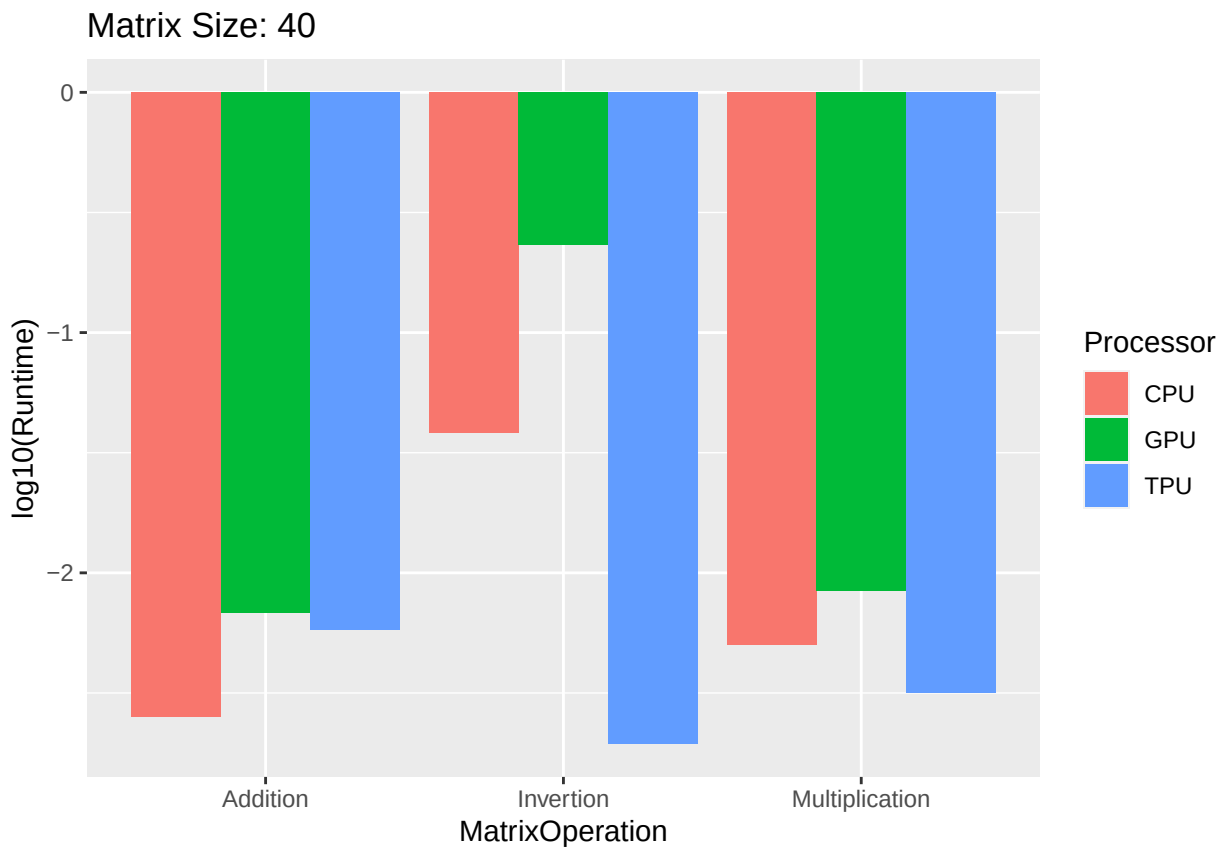
```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



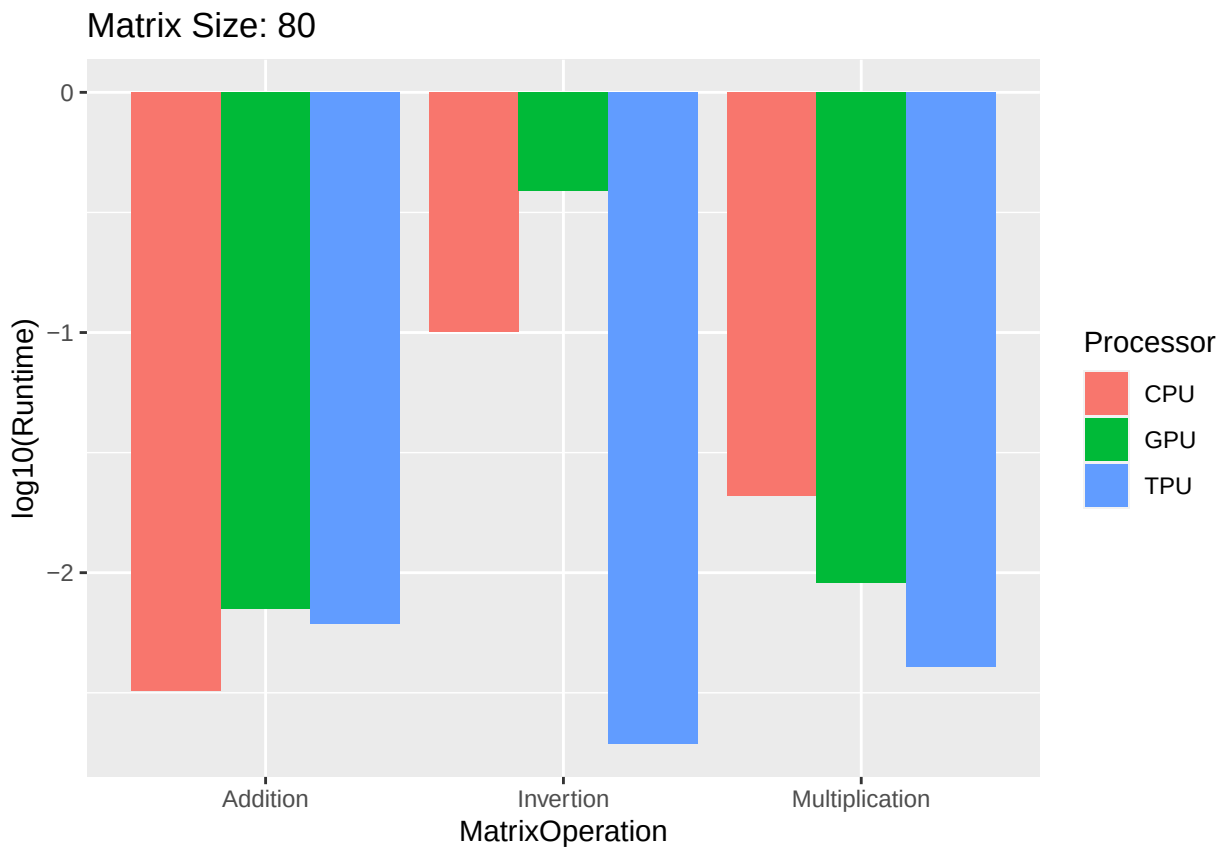

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



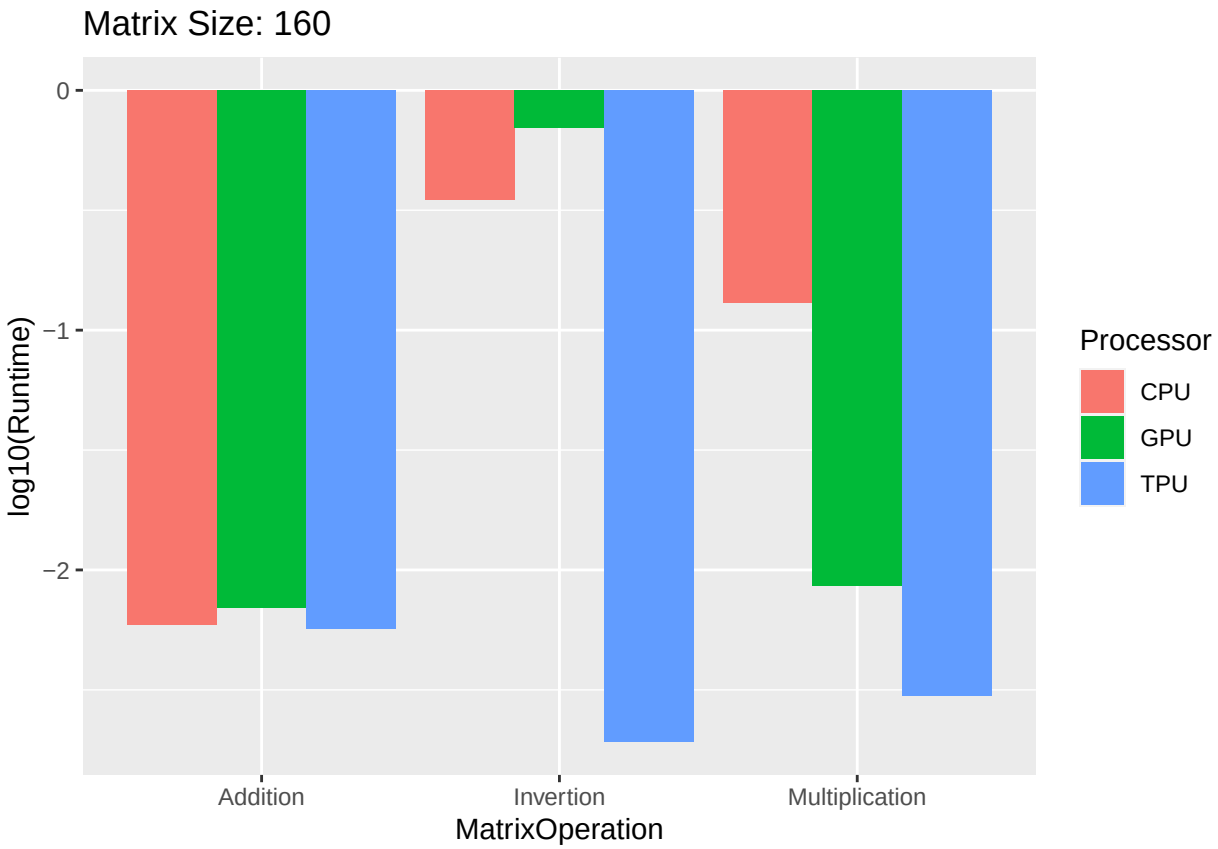

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



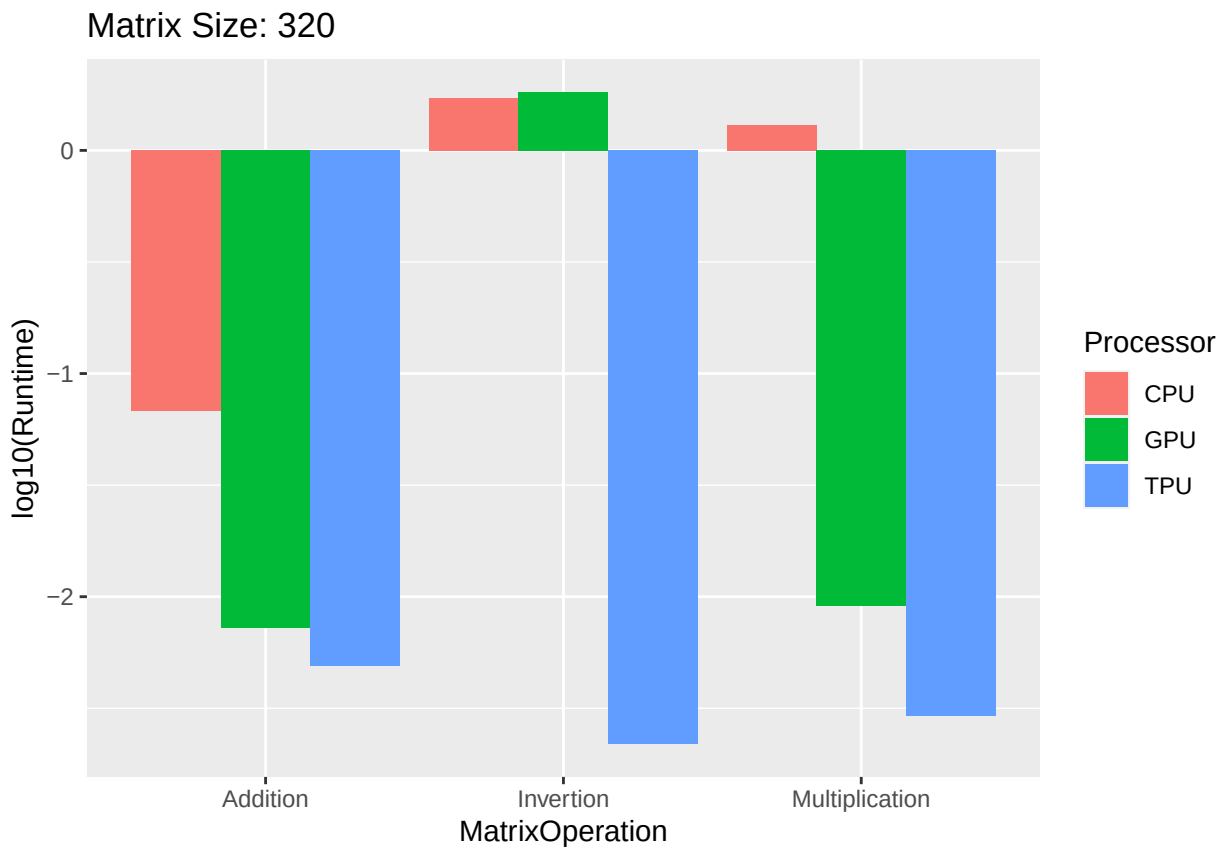

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



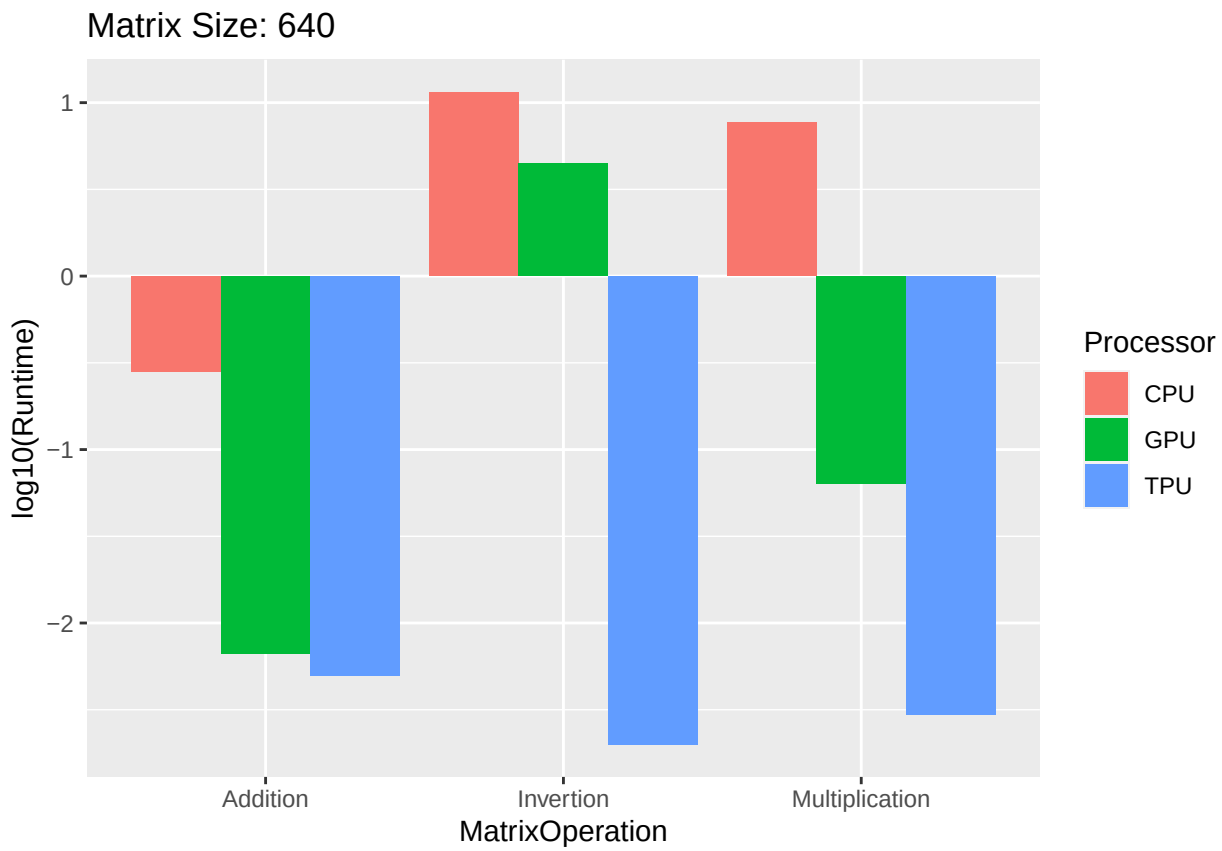

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



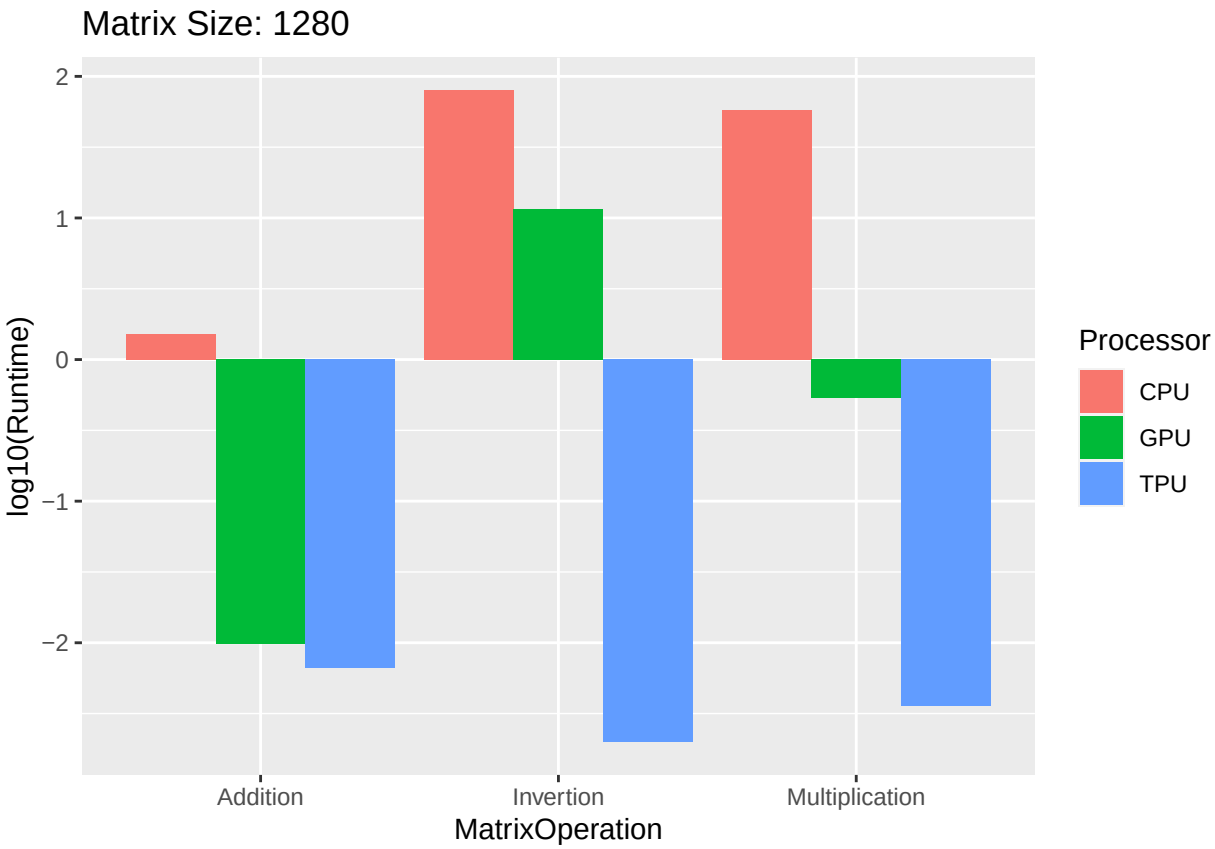

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```

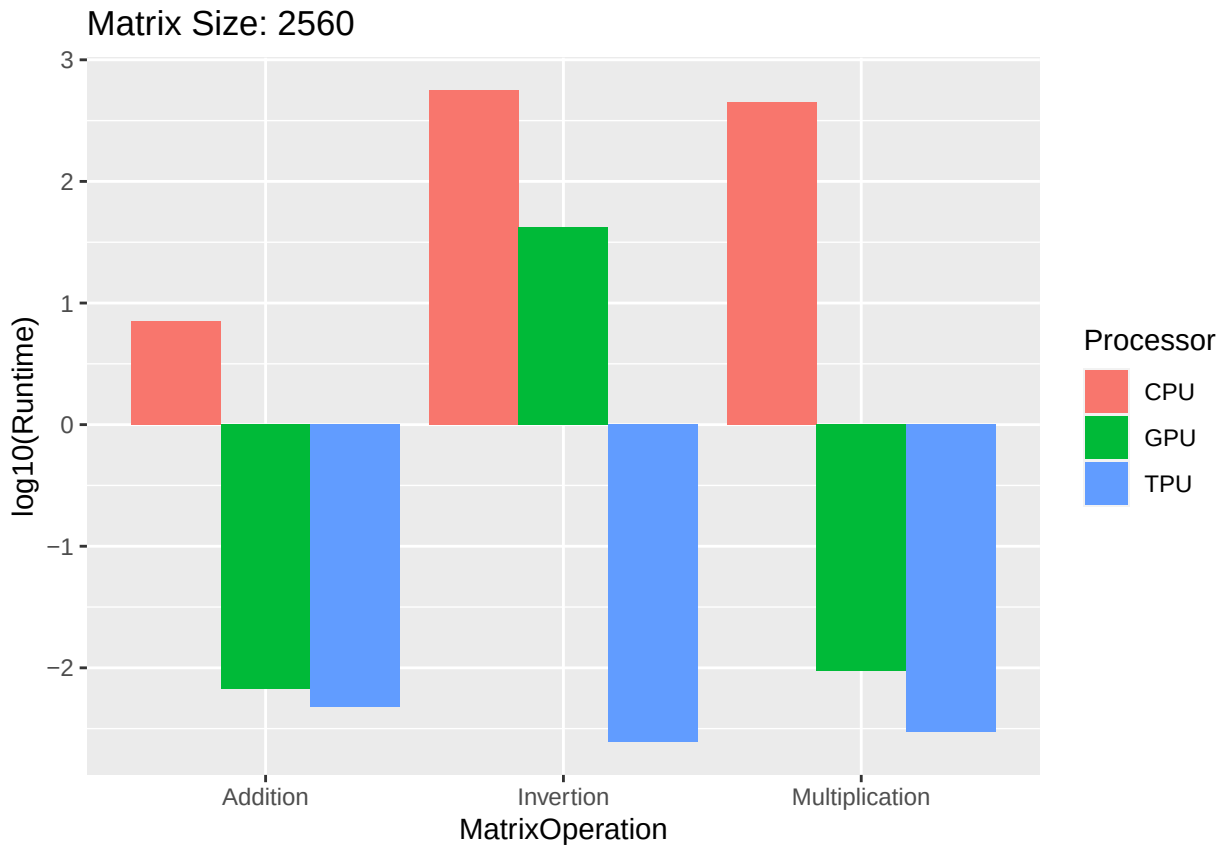



```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```



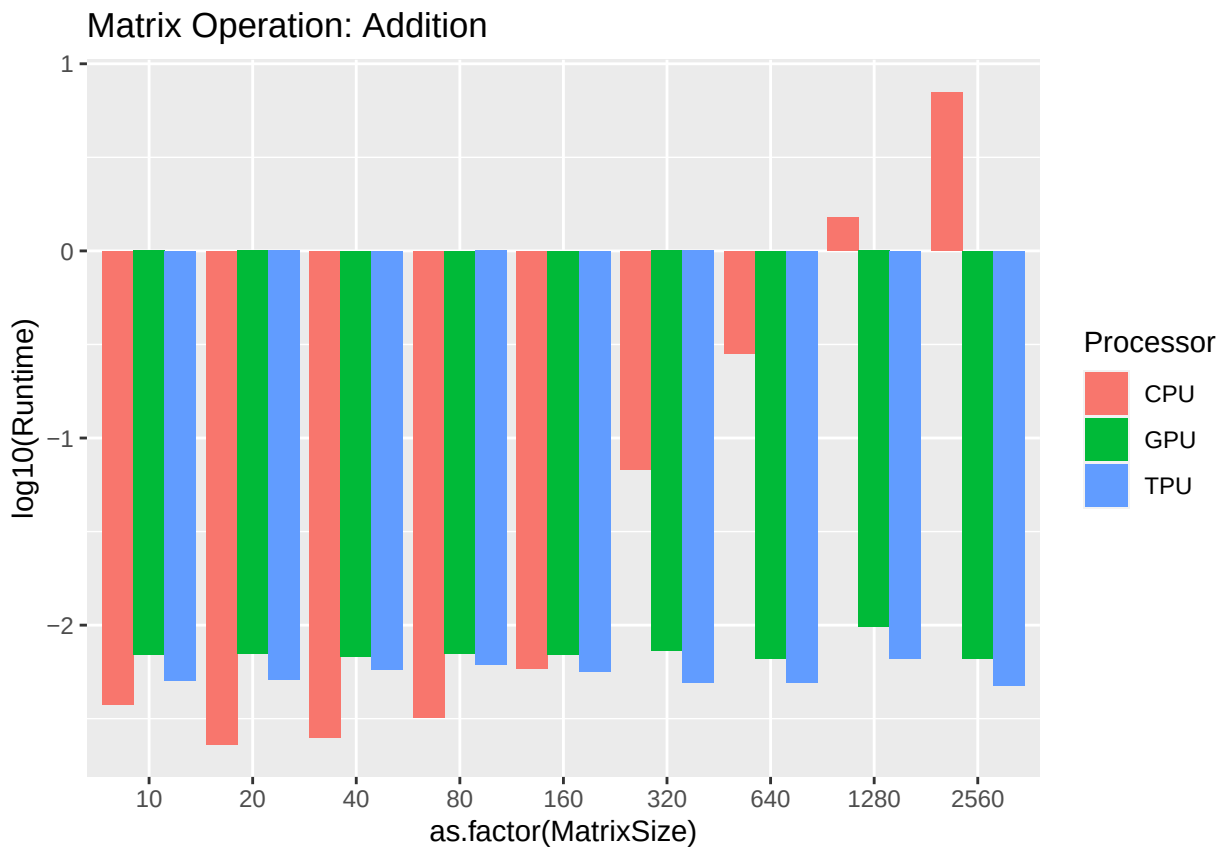

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```


Matrix Size: 1280
log10(Runtime)
2
1
0
−1
−2
Addition
Invertion
Multiplication
MatrixOperation
Processor
CPU
GPU
TPU

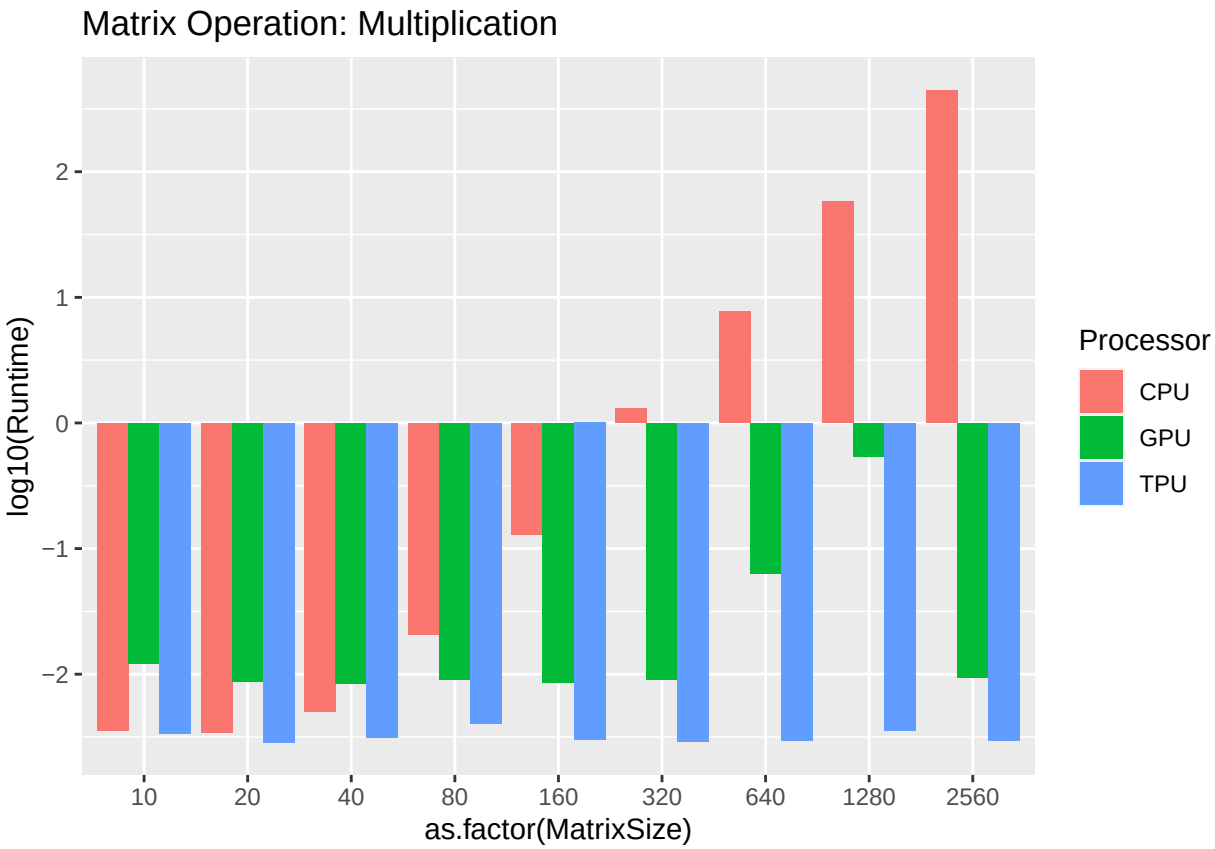



```
for(operation in unique(data$MatrixOperation)){
  p <- data %>%
    filter(MatrixOperation == operation, MatrixSize <= 2560) %>%
    group_by(MatrixSize, MatrixOperation, Processor) %>%
    summarize(Runtime = mean(Runtime)) %>%
    ggplot(aes(x = as.factor(MatrixSize), y = log10(Runtime))) +
    #geom_boxplot(aes(fill = as.factor(Processor))) +
    geom_bar(aes(fill = as.factor(Processor)), stat = "identity",
             alpha = 1, position = "dodge") +
    ggtitle(paste0("Matrix Operation: ", operation)) +
    #facet_wrap( ~ MatrixOperation, scales = "free", nrow = 1) +
    guides(fill=guide_legend(title = "Processor"))
  print(p)
}
```

```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```




```
## `summarise()` has grouped output by 'MatrixSize', 'MatrixOperation'. You can override using the `.gr
```


Matrix Operation: Multiplication
log10(Runtime)
2
1
0
−1
−2
10
20
40
80
160
320
640
1280
2560
as.factor(MatrixSize)
Processor
CPU
GPU
TPU

Pros & Cons of Each Processor

```
df_cpu <- data[data$Processor == "TPU",]
lm(Runtime ~ MatrixSize + as.factor(MatrixOperation), data = df_cpu) %>%
  summary()
```

```
##
## Call:
## lm(formula = Runtime ~ MatrixSize + as.factor(MatrixOperation),
##     data = df_cpu)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0008794 -0.0003316 -0.0002244 -0.0000993  0.0041166
##
## Coefficients:
##                                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                                 5.460e-03  1.389e-04  39.296   <2e-16
## MatrixSize                                 -2.635e-08  9.226e-08  -0.286    0.776
## as.factor(MatrixOperation)Invertion        -3.320e-03  1.820e-04 -18.243   <2e-16
## as.factor(MatrixOperation)Multiplication -2.238e-03  1.820e-04 -12.296   <2e-16
##
## (Intercept)                                ***
```

```
## MatrixSize
## as.factor(MatrixOperation)Invertion      ***
## as.factor(MatrixOperation)Multiplication ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0008633 on 131 degrees of freedom
## Multiple R-squared:  0.7256, Adjusted R-squared:  0.7193
## F-statistic: 115.4 on 3 and 131 DF,  p-value: < 2.2e-16
```