



Escuela de Ingeniería en Computación

Inteligencia Artificial - IC6200 - Grupo 2

Proyecto de Investigación: Convolutional Neural Networks

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Conclusiones

- La idea del tutorial fue realizar una red neuronal convolucional que pudiera clasificar imágenes de 32x32 (RGB) en 10 categorías diferentes: avión, automóvil, pájaro, gato, venado, perro, rana, caballo, barco y camión.
- El archivo con el que se entrena y prueba la red neuronal consta de 60000 imágenes, 10000 de cada categoría, 50000 son para entrenamiento y 10000 para prueba. Las imágenes son a color y de un tamaño definido (32px X 32px).
- La red es entrenada con el algoritmo descendiente del gradiente.
- Como el entrenamiento es bastante pesado, se implementaron 16 hilos para acelerar el pre-procesamiento de las imágenes, entrando cada uno en una cola para entrenar la red la cola la provee TensorFlow.
- La red se entrenó con 10000 steps, teniendo una duración de 4 horas con 30 minutos aproximadamente. Sin embargo, en el TensorBoard aparece el Learning Rate como un escalar constante.
- La red neuronal es bastante confiable, cuando se probó retornó los resultados con una precisión del 81% (aproximadamente), lo cual es una buena estadística.

Aplicación a un problema real

En medios de transporte para controlar la cantidad de distintos tipos de medios de transporte que transitan sobre una carretera, se puede utilizar esta red neuronal para el reconocimiento de los mismos y saber que tanto transita dicho vehículo. Se podría realizar un análisis estadístico y mejorar las carreteras para facilitar el transporte del lugar más transitado y así lograr evitar que haya tanto tráfico.

Screenshots

Descarga del paquete de imágenes cifar10.

```
C:\Users\Stephannie\Documents\GitHub\models\tutorials\image\cifar10>py cifar10_train.py
>> Downloading cifar-10-binary.tar.gz 100.0%
Successfully downloaded cifar-10-binary.tar.gz 170052171 bytes.
```

Comienzo del entrenamiento, el error es bastante alto.

```
2017-11-11 23:46:03.965746: step 0, loss = 4.68 (105.8 examples/sec; 1.210 sec/batch)
2017-11-11 23:46:21.285497: step 10, loss = 4.64 (73.9 examples/sec; 1.732 sec/batch)
2017-11-11 23:46:37.344276: step 20, loss = 4.50 (79.7 examples/sec; 1.606 sec/batch)
2017-11-11 23:46:51.903476: step 30, loss = 4.35 (87.9 examples/sec; 1.456 sec/batch)
2017-11-11 23:47:06.336495: step 40, loss = 4.48 (88.7 examples/sec; 1.443 sec/batch)
2017-11-11 23:47:21.019934: step 50, loss = 4.37 (87.2 examples/sec; 1.468 sec/batch)
2017-11-11 23:47:35.716973: step 60, loss = 4.21 (87.1 examples/sec; 1.470 sec/batch)
2017-11-11 23:47:50.611658: step 70, loss = 4.31 (85.9 examples/sec; 1.489 sec/batch)
2017-11-11 23:48:19.558055: step 80, loss = 3.85 (90.7 examples/sec; 1.411 sec/batch)
2017-11-11 23:48:35.708334: step 90, loss = 3.19 (78.3 examples/sec; 1.635 sec/batch)
2017-11-11 23:48:50.424201: step 100, loss = 3.08 (87.0 examples/sec; 1.472 sec/batch)
2017-11-11 23:49:06.439086: step 110, loss = 3.12 (79.9 examples/sec; 1.601 sec/batch)
2017-11-11 23:49:24.275356: step 120, loss = 3.16 (71.8 examples/sec; 1.784 sec/batch)
2017-11-11 23:49:40.560799: step 130, loss = 3.22 (78.6 examples/sec; 1.629 sec/batch)
2017-11-11 23:49:55.557856: step 140, loss = 2.72 (85.4 examples/sec; 1.500 sec/batch)
2017-11-12 00:00:10.338101: step 150, loss = 2.89 (86.6 examples/sec; 1.478 sec/batch)
2017-11-12 00:00:25.235152: step 160, loss = 3.02 (85.9 examples/sec; 1.490 sec/batch)
2017-11-12 00:00:40.509358: step 170, loss = 2.93 (83.8 examples/sec; 1.527 sec/batch)
2017-11-12 00:00:57.091705: step 180, loss = 2.93 (77.2 examples/sec; 1.658 sec/batch)
2017-11-12 00:01:11.640898: step 190, loss = 2.87 (88.0 examples/sec; 1.455 sec/batch)
2017-11-12 00:01:26.537944: step 200, loss = 2.80 (85.9 examples/sec; 1.490 sec/batch)
2017-11-12 00:01:43.495066: step 210, loss = 3.00 (75.5 examples/sec; 1.696 sec/batch)
2017-11-12 00:01:59.472192: step 220, loss = 2.91 (80.1 examples/sec; 1.598 sec/batch)
2017-11-12 00:02:13.565996: step 230, loss = 2.93 (90.8 examples/sec; 1.409 sec/batch)
2017-11-12 00:02:28.791069: step 240, loss = 2.90 (84.1 examples/sec; 1.523 sec/batch)
2017-11-12 00:02:45.627325: step 250, loss = 2.85 (76.0 examples/sec; 1.684 sec/batch)
2017-11-12 00:03:04.825097: step 260, loss = 3.12 (66.7 examples/sec; 1.920 sec/batch)
2017-11-12 00:03:17.989593: step 270, loss = 2.91 (97.2 examples/sec; 1.316 sec/batch)
2017-11-12 00:03:32.522619: step 280, loss = 2.72 (88.1 examples/sec; 1.453 sec/batch)
2017-11-12 00:03:47.770907: step 290, loss = 2.80 (83.9 examples/sec; 1.525 sec/batch)
2017-11-12 00:04:03.817336: step 300, loss = 2.74 (79.8 examples/sec; 1.605 sec/batch)
2017-11-12 00:04:19.361824: step 310, loss = 2.72 (82.3 examples/sec; 1.554 sec/batch)
2017-11-12 00:04:33.246452: step 320, loss = 2.66 (92.2 examples/sec; 1.388 sec/batch)
2017-11-12 00:04:46.347376: step 330, loss = 2.89 (97.7 examples/sec; 1.310 sec/batch)
2017-11-12 00:04:59.973833: step 340, loss = 2.73 (93.9 examples/sec; 1.363 sec/batch)
2017-11-12 00:05:15.238909: step 350, loss = 2.69 (83.9 examples/sec; 1.527 sec/batch)
2017-11-12 00:05:30.269176: step 360, loss = 2.82 (85.2 examples/sec; 1.503 sec/batch)
2017-11-12 00:05:43.346099: step 370, loss = 2.80 (97.9 examples/sec; 1.308 sec/batch)
2017-11-12 00:05:56.812926: step 380, loss = 2.55 (95.0 examples/sec; 1.347 sec/batch)
2017-11-12 00:06:11.795877: step 390, loss = 2.62 (85.4 examples/sec; 1.498 sec/batch)
2017-11-12 00:06:25.096814: step 400, loss = 2.61 (96.2 examples/sec; 1.330 sec/batch)
2017-11-12 00:06:38.251435: step 410, loss = 2.56 (97.3 examples/sec; 1.315 sec/batch)
2017-11-12 00:06:51.348360: step 420, loss = 2.63 (97.7 examples/sec; 1.310 sec/batch)
2017-11-12 00:07:04.388158: step 430, loss = 2.71 (98.2 examples/sec; 1.304 sec/batch)
2017-11-12 00:07:17.521087: step 440, loss = 2.48 (97.5 examples/sec; 1.313 sec/batch)
2017-11-12 00:07:30.718016: step 450, loss = 2.48 (97.0 examples/sec; 1.320 sec/batch)
2017-11-12 00:07:44.080977: step 460, loss = 2.60 (95.8 examples/sec; 1.336 sec/batch)
2017-11-12 00:07:57.589930: step 470, loss = 2.58 (94.8 examples/sec; 1.351 sec/batch)
2017-11-12 00:08:10.849638: step 480, loss = 2.60 (96.5 examples/sec; 1.326 sec/batch)
2017-11-12 00:08:23.974561: step 490, loss = 2.64 (97.5 examples/sec; 1.312 sec/batch)
2017-11-12 00:08:37.006634: step 500, loss = 2.50 (98.2 examples/sec; 1.303 sec/batch)
2017-11-12 00:08:50.752833: step 510, loss = 2.41 (93.1 examples/sec; 1.375 sec/batch)
```

Se observa como el error va disminuyendo.

```
2017-11-12 00:31:02.619625: step 1930, loss = 1.62 (94.0 examples/sec; 1.362 sec/batch)
2017-11-12 00:31:17.957635: step 1940, loss = 1.60 (83.5 examples/sec; 1.534 sec/batch)
2017-11-12 00:31:32.778682: step 1950, loss = 1.57 (86.4 examples/sec; 1.482 sec/batch)
2017-11-12 00:31:46.043617: step 1960, loss = 1.86 (96.5 examples/sec; 1.326 sec/batch)
2017-11-12 00:31:59.696583: step 1970, loss = 1.84 (93.8 examples/sec; 1.365 sec/batch)
2017-11-12 00:32:13.152722: step 1980, loss = 1.55 (95.1 examples/sec; 1.346 sec/batch)
2017-11-12 00:32:26.561667: step 1990, loss = 1.69 (95.5 examples/sec; 1.341 sec/batch)
2017-11-12 00:32:40.134625: step 2000, loss = 1.66 (94.3 examples/sec; 1.357 sec/batch)
2017-11-12 00:32:53.464163: step 2010, loss = 1.61 (96.0 examples/sec; 1.333 sec/batch)
2017-11-12 00:33:06.665094: step 2020, loss = 1.59 (97.0 examples/sec; 1.320 sec/batch)
2017-11-12 00:33:19.892754: step 2030, loss = 1.54 (96.8 examples/sec; 1.323 sec/batch)
2017-11-12 00:33:33.205694: step 2040, loss = 1.63 (96.1 examples/sec; 1.331 sec/batch)
2017-11-12 00:33:46.446627: step 2050, loss = 1.54 (96.7 examples/sec; 1.324 sec/batch)
2017-11-12 00:33:59.714320: step 2060, loss = 1.65 (96.5 examples/sec; 1.327 sec/batch)
2017-11-12 00:34:13.023260: step 2070, loss = 1.58 (96.2 examples/sec; 1.331 sec/batch)
2017-11-12 00:34:26.374522: step 2080, loss = 1.70 (95.9 examples/sec; 1.335 sec/batch)
2017-11-12 00:34:39.807470: step 2090, loss = 1.82 (95.3 examples/sec; 1.343 sec/batch)
2017-11-12 00:34:54.987785: step 2100, loss = 1.63 (84.3 examples/sec; 1.518 sec/batch)
2017-11-12 00:35:10.528883: step 2110, loss = 1.61 (82.4 examples/sec; 1.554 sec/batch)
2017-11-12 00:35:24.181211: step 2120, loss = 1.52 (93.8 examples/sec; 1.365 sec/batch)
2017-11-12 00:35:37.526182: step 2130, loss = 1.70 (95.9 examples/sec; 1.334 sec/batch)
2017-11-12 00:35:50.795116: step 2140, loss = 1.58 (96.5 examples/sec; 1.327 sec/batch)
2017-11-12 00:36:04.308360: step 2150, loss = 1.62 (94.7 examples/sec; 1.351 sec/batch)
2017-11-12 00:36:22.225628: step 2160, loss = 1.64 (71.4 examples/sec; 1.792 sec/batch)
2017-11-12 00:36:36.903378: step 2170, loss = 1.74 (87.2 examples/sec; 1.468 sec/batch)
2017-11-12 00:36:50.120311: step 2180, loss = 1.56 (96.8 examples/sec; 1.322 sec/batch)
2017-11-12 00:37:03.755783: step 2190, loss = 1.67 (93.9 examples/sec; 1.364 sec/batch)
2017-11-12 00:37:17.128727: step 2200, loss = 1.63 (95.7 examples/sec; 1.337 sec/batch)
2017-11-12 00:37:30.281655: step 2210, loss = 1.58 (97.3 examples/sec; 1.315 sec/batch)
2017-11-12 00:37:43.392110: step 2220, loss = 1.62 (97.6 examples/sec; 1.311 sec/batch)
2017-11-12 00:37:56.445032: step 2230, loss = 1.67 (98.1 examples/sec; 1.305 sec/batch)
2017-11-12 00:38:09.541565: step 2240, loss = 1.55 (97.7 examples/sec; 1.310 sec/batch)
2017-11-12 00:38:22.758498: step 2250, loss = 1.70 (96.8 examples/sec; 1.322 sec/batch)
2017-11-12 00:38:36.130448: step 2260, loss = 1.73 (95.7 examples/sec; 1.337 sec/batch)
2017-11-12 00:38:49.745485: step 2270, loss = 1.49 (94.0 examples/sec; 1.362 sec/batch)
2017-11-12 00:39:03.398969: step 2280, loss = 1.63 (93.7 examples/sec; 1.365 sec/batch)
2017-11-12 00:39:18.282024: step 2290, loss = 1.65 (86.0 examples/sec; 1.488 sec/batch)
2017-11-12 00:39:37.583707: step 2300, loss = 1.44 (66.3 examples/sec; 1.930 sec/batch)
2017-11-12 00:41:32.226534: step 2310, loss = 1.39 (11.2 examples/sec; 11.464 sec/batch)
2017-11-12 00:42:17.755029: step 2320, loss = 1.48 (28.1 examples/sec; 4.553 sec/batch)
2017-11-12 00:43:00.405377: step 2330, loss = 1.80 (30.0 examples/sec; 4.265 sec/batch)
2017-11-12 00:43:57.664945: step 2340, loss = 1.39 (22.4 examples/sec; 5.726 sec/batch)
2017-11-12 00:44:59.430894: step 2350, loss = 1.48 (20.7 examples/sec; 6.177 sec/batch)
2017-11-12 00:45:50.113957: step 2360, loss = 1.50 (25.3 examples/sec; 5.068 sec/batch)
```

El error varía mucho entre un paso y otro, sube o baja pero termino en 1.03

```
2017-11-12 14:43:39.607926: step 9440, loss = 0.68 (83.9 examples/sec; 1.526 sec/batch)
2017-11-12 14:43:55.855487: step 9450, loss = 0.67 (78.8 examples/sec; 1.625 sec/batch)
2017-11-12 14:44:13.738211: step 9460, loss = 0.95 (71.6 examples/sec; 1.788 sec/batch)
2017-11-12 14:44:32.321433: step 9470, loss = 0.87 (68.9 examples/sec; 1.858 sec/batch)
2017-11-12 14:44:49.797868: step 9480, loss = 0.79 (73.2 examples/sec; 1.748 sec/batch)
2017-11-12 14:45:03.838860: step 9490, loss = 0.90 (91.2 examples/sec; 1.404 sec/batch)
2017-11-12 14:45:20.003361: step 9500, loss = 0.85 (79.2 examples/sec; 1.616 sec/batch)
2017-11-12 14:45:34.389598: step 9510, loss = 0.95 (89.0 examples/sec; 1.439 sec/batch)
2017-11-12 14:45:51.473753: step 9520, loss = 0.92 (74.9 examples/sec; 1.708 sec/batch)
2017-11-12 14:46:08.335751: step 9530, loss = 0.80 (75.9 examples/sec; 1.686 sec/batch)
2017-11-12 14:46:22.035499: step 9540, loss = 0.71 (93.4 examples/sec; 1.370 sec/batch)
2017-11-12 14:46:34.812590: step 9550, loss = 0.86 (100.2 examples/sec; 1.278 sec/batch)
2017-11-12 14:46:48.486320: step 9560, loss = 0.90 (93.6 examples/sec; 1.367 sec/batch)
2017-11-12 14:47:01.576634: step 9570, loss = 0.93 (97.8 examples/sec; 1.309 sec/batch)
2017-11-12 14:47:17.033632: step 9580, loss = 0.82 (82.8 examples/sec; 1.546 sec/batch)
2017-11-12 14:47:33.143815: step 9590, loss = 0.96 (79.5 examples/sec; 1.611 sec/batch)
2017-11-12 14:47:48.007387: step 9600, loss = 1.11 (86.1 examples/sec; 1.486 sec/batch)
2017-11-12 14:48:03.429849: step 9610, loss = 0.82 (83.0 examples/sec; 1.542 sec/batch)
2017-11-12 14:48:17.703006: step 9620, loss = 0.95 (89.7 examples/sec; 1.427 sec/batch)
2017-11-12 14:48:30.874378: step 9630, loss = 0.77 (97.2 examples/sec; 1.317 sec/batch)
2017-11-12 14:48:45.986130: step 9640, loss = 0.77 (84.7 examples/sec; 1.511 sec/batch)
2017-11-12 14:48:59.676871: step 9650, loss = 0.94 (93.5 examples/sec; 1.369 sec/batch)
2017-11-12 14:49:13.449671: step 9660, loss = 1.17 (92.9 examples/sec; 1.377 sec/batch)
2017-11-12 14:49:26.470936: step 9670, loss = 0.92 (98.3 examples/sec; 1.302 sec/batch)
2017-11-12 14:49:40.261748: step 9680, loss = 0.89 (92.8 examples/sec; 1.379 sec/batch)
2017-11-12 14:49:53.136910: step 9690, loss = 0.80 (99.4 examples/sec; 1.288 sec/batch)
2017-11-12 14:50:06.954742: step 9700, loss = 0.84 (92.6 examples/sec; 1.382 sec/batch)
2017-11-12 14:50:19.847916: step 9710, loss = 1.01 (99.3 examples/sec; 1.289 sec/batch)
2017-11-12 14:50:32.865179: step 9720, loss = 0.99 (98.3 examples/sec; 1.302 sec/batch)
2017-11-12 14:50:46.547914: step 9730, loss = 0.90 (93.5 examples/sec; 1.368 sec/batch)
2017-11-12 14:51:00.040514: step 9740, loss = 0.99 (94.9 examples/sec; 1.349 sec/batch)
2017-11-12 14:51:13.889369: step 9750, loss = 0.94 (92.4 examples/sec; 1.385 sec/batch)
2017-11-12 14:51:27.446015: step 9760, loss = 1.01 (94.4 examples/sec; 1.356 sec/batch)
2017-11-12 14:51:41.023678: step 9770, loss = 0.99 (94.3 examples/sec; 1.358 sec/batch)
2017-11-12 14:51:54.455232: step 9780, loss = 0.95 (95.3 examples/sec; 1.343 sec/batch)
2017-11-12 14:52:08.038901: step 9790, loss = 0.77 (94.2 examples/sec; 1.358 sec/batch)
2017-11-12 14:52:23.908795: step 9800, loss = 0.99 (80.7 examples/sec; 1.587 sec/batch)
2017-11-12 14:52:37.311332: step 9810, loss = 0.93 (95.5 examples/sec; 1.340 sec/batch)
2017-11-12 14:52:50.456685: step 9820, loss = 0.87 (97.4 examples/sec; 1.315 sec/batch)
2017-11-12 14:53:03.530988: step 9830, loss = 1.04 (97.9 examples/sec; 1.307 sec/batch)
2017-11-12 14:53:16.878486: step 9840, loss = 0.85 (95.9 examples/sec; 1.335 sec/batch)
2017-11-12 14:53:30.823409: step 9850, loss = 0.91 (91.8 examples/sec; 1.394 sec/batch)
2017-11-12 14:53:43.964759: step 9860, loss = 1.03 (97.4 examples/sec; 1.314 sec/batch)
2017-11-12 14:53:57.134129: step 9870, loss = 0.90 (97.2 examples/sec; 1.317 sec/batch)
2017-11-12 14:54:10.830874: step 9880, loss = 0.96 (93.5 examples/sec; 1.370 sec/batch)
2017-11-12 14:54:24.246423: step 9890, loss = 0.89 (95.4 examples/sec; 1.342 sec/batch)
2017-11-12 14:54:38.103281: step 9900, loss = 0.93 (92.4 examples/sec; 1.386 sec/batch)
2017-11-12 14:54:51.721970: step 9910, loss = 0.89 (94.0 examples/sec; 1.362 sec/batch)
2017-11-12 14:55:05.238588: step 9920, loss = 0.86 (94.7 examples/sec; 1.352 sec/batch)
2017-11-12 14:55:18.747200: step 9930, loss = 0.80 (94.8 examples/sec; 1.351 sec/batch)
2017-11-12 14:55:32.675111: step 9940, loss = 0.94 (91.9 examples/sec; 1.393 sec/batch)
2017-11-12 14:55:46.876214: step 9950, loss = 0.86 (90.1 examples/sec; 1.420 sec/batch)
2017-11-12 14:56:00.506913: step 9960, loss = 1.12 (93.9 examples/sec; 1.363 sec/batch)
2017-11-12 14:56:13.894439: step 9970, loss = 0.85 (95.6 examples/sec; 1.339 sec/batch)
2017-11-12 14:56:27.462885: step 9980, loss = 1.11 (94.3 examples/sec; 1.357 sec/batch)
2017-11-12 14:56:40.964492: step 9990, loss = 1.03 (94.8 examples/sec; 1.350 sec/batch)
```

Se probó la red neuronal con 10000 imágenes y se obtuvo una precisión promedio de 81%.

```
C:\Users\Stephannie\Documents\GitHub\models\tutorials\image\cifar10>py cifar10_eval.py
2017-11-12 15:17:59.356712: I C:\tf_jenkins\home\workspace\rel-win\M\windows\PY\36\tensor
t this TensorFlow binary was not compiled to use: AVX AVX2
2017-11-12 15:18:24.259289: precision @ 1 = 0.818
```

Graficos

