

julia Problem4.jl

```
opts=(:batchsize, 100)(:epochs, 10)(:winit, 0.1)(:lr, 0.5)(:hidden, Int64[])
INFO: Loading MNIST...
% Total   % Received % Xferd Average Speed   Time    Time     Time Current
          Dload  Upload  Total  Spent  Left  Speed
100 9680k 100 9680k   0    0  940k    0 0:00:10 0:00:10 --:--:-- 822k
% Total   % Received % Xferd Average Speed   Time    Time     Time Current
          Dload  Upload  Total  Spent  Left  Speed
100 1610k 100 1610k   0    0 1121k    0 0:00:01 0:00:01 --:--:-- 1122k
% Total   % Received % Xferd Average Speed   Time    Time     Time Current
          Dload  Upload  Total  Spent  Left  Speed
100 28881 100 28881   0    0  395k    0 --:--:-- --:--:-- --:--:-- 397k
% Total   % Received % Xferd Average Speed   Time    Time     Time Current
          Dload  Upload  Total  Spent  Left  Speed
100 4542 100 4542   0    0 72165    0 --:--:-- --:--:-- --:--:-- 73258
(:epoch, 0, :trn, (0.09768333f0, 2.869472f0), :tst, (0.0971f0, 2.8795366f0))
(:epoch, 1, :trn, (0.90108335f0, 0.33277346843034583), :tst, (0.9049f0, 0.3238402942176069))
(:epoch, 2, :trn, (0.90783334f0, 0.3103432158332508), :tst, (0.9097f0, 0.3085217959752772))
(:epoch, 3, :trn, (0.9113167f0, 0.2999700789899892), :tst, (0.9107f0, 0.30287384177086674))
(:epoch, 4, :trn, (0.9134f0, 0.29346055065167476), :tst, (0.9117f0, 0.29980739913380355))
(:epoch, 5, :trn, (0.915f0, 0.28876208460287417), :tst, (0.913f0, 0.29779067234728296))
(:epoch, 6, :trn, (0.91611665f0, 0.2850995468149771), :tst, (0.9147f0, 0.29632166277655664))
(:epoch, 7, :trn, (0.91751665f0, 0.28210941224426694), :tst, (0.9148f0, 0.2951923589223245))
(:epoch, 8, :trn, (0.91821665f0, 0.27959406696393174), :tst, (0.9147f0, 0.2942997749374704))
(:epoch, 9, :trn, (0.91896665f0, 0.2774335801574051), :tst, (0.9149f0, 0.29358458879694344))
(:epoch, 10, :trn, (0.91926664f0, 0.27554889105819924), :tst, (0.9151f0,
0.29300820530955446))
44.378748 seconds (7.43 M allocations: 2.303 GiB, 1.56% gc time)
```

julia Problem4.jl --hidden 32

```
opts=(:batchsize, 100)(:epochs, 10)(:winit, 0.1)(:lr, 0.5)(:hidden, [32])
INFO: Loading MNIST...
(:epoch, 0, :trn, (0.06035f0, 2.33586f0), :tst, (0.0537f0, 2.343605f0))
(:epoch, 1, :trn, (0.93315f0, 0.2157895033483524), :tst, (0.9282f0, 0.21917876140175835))
(:epoch, 2, :trn, (0.9497f0, 0.16036084864607292), :tst, (0.9458f0, 0.17191437327372364))
(:epoch, 3, :trn, (0.95975f0, 0.1292820363420145), :tst, (0.9539f0, 0.14887324649088368))
```

```
(:epoch, 4, :trn, (0.96451664f0, 0.11437278570896435), :tst, (0.9573f0,
0.14006985030691804))
(:epoch, 5, :trn, (0.9676167f0, 0.10383996544992638), :tst, (0.9595f0, 0.13568410135864073))
(:epoch, 6, :trn, (0.96968335f0, 0.09589869232463481), :tst, (0.9614f0, 0.1330760787924179))
(:epoch, 7, :trn, (0.97083336f0, 0.09068430883358843), :tst, (0.962f0, 0.13327227336481867))
(:epoch, 8, :trn, (0.97293335f0, 0.0851949879252251), :tst, (0.9641f0, 0.13187889845628734))
(:epoch, 9, :trn, (0.9752667f0, 0.07820585050802557), :tst, (0.9657f0, 0.12928239247059078))
(:epoch, 10, :trn, (0.97496665f0, 0.07760365977553468), :tst, (0.9648f0,
0.13326422330246457))
124.888347 seconds (9.69 M allocations: 5.980 GiB, 0.84% gc time)
```

julia Problem4.jl --hidden 64

```
opts=(:batchsize, 100)(:epochs, 10)(:winit, 0.1)(:lr, 0.5)(:hidden, [64])
INFO: Loading MNIST...
(:epoch, 0, :trn, (0.10346667f0, 2.4339373f0), :tst, (0.101f0, 2.4297583f0))
(:epoch, 1, :trn, (0.93993336f0, 0.1918485451417435), :tst, (0.9383f0, 0.19680877156377527))
(:epoch, 2, :trn, (0.9600667f0, 0.1277611680726482), :tst, (0.9559f0, 0.13965449433418578))
(:epoch, 3, :trn, (0.96778333f0, 0.10215927391584916), :tst, (0.9607f0, 0.1246097603511199))
(:epoch, 4, :trn, (0.9706333f0, 0.08917634333740368), :tst, (0.9617f0, 0.12038377772120043))
(:epoch, 5, :trn, (0.9748833f0, 0.07862892631568145), :tst, (0.9649f0, 0.11492593692838868))
(:epoch, 6, :trn, (0.97705f0, 0.07124935835191788), :tst, (0.9651f0, 0.11307289034713397))
(:epoch, 7, :trn, (0.98071665f0, 0.05963261123613527), :tst, (0.9666f0,
0.10537905940245612))
(:epoch, 8, :trn, (0.9822f0, 0.05455496359600824), :tst, (0.9691f0, 0.10406252387865243))
(:epoch, 9, :trn, (0.9827667f0, 0.05216210171592266), :tst, (0.9669f0, 0.10576432005160566))
(:epoch, 10, :trn, (0.98455f0, 0.04732145518825879), :tst, (0.9682f0, 0.10429395102122592))
235.090864 seconds (9.69 M allocations: 10.607 GiB, 0.70% gc time)
```

julia Problem4.jl --hidden 64 64 64 64

```
opts=(:batchsize, 100)(:epochs, 10)(:winit, 0.1)(:lr, 0.5)(:hidden, [64, 64, 64, 64])
INFO: Loading MNIST...
(:epoch, 0, :trn, (0.11968333f0, 2.298824f0), :tst, (0.1161f0, 2.3000147f0))
(:epoch, 1, :trn, (0.84455f0, 0.6008807667273283), :tst, (0.8449f0, 0.6097532588957177))
(:epoch, 2, :trn, (0.95281667f0, 0.16518190381662337), :tst, (0.9479f0,
0.17714941453376895))
(:epoch, 3, :trn, (0.9541f0, 0.1633855644448814), :tst, (0.9474f0, 0.18178857633542703))
(:epoch, 4, :trn, (0.9673333f0, 0.10945467186478061), :tst, (0.9583f0, 0.14722963840389156))
(:epoch, 5, :trn, (0.9741833f0, 0.08855904423786118), :tst, (0.9624f0, 0.13942035219010399))
```

```
(:epoch, 6, :trn, (0.9773333f0, 0.07464272078779659), :tst, (0.9676f0, 0.12714150256587323))
(:epoch, 7, :trn, (0.97825f0, 0.07377635578599058), :tst, (0.964f0, 0.14257408245057762))
(:epoch, 8, :trn, (0.9809833f0, 0.062014950950341416), :tst, (0.9679f0,
0.12577395571350952))
(:epoch, 9, :trn, (0.98328334f0, 0.05450968405055048), :tst, (0.968f0, 0.1294310998640219))
(:epoch, 10, :trn, (0.9816833f0, 0.06294057372856929), :tst, (0.9675f0,
0.13568442434336733))
244.611663 seconds (15.51 M allocations: 19.826 GiB, 0.93% gc time)
```

julia Problem4.jl --lr 4.0

```
opts=(:batchsize, 100)(:epochs, 10)(:winit, 0.1)(:lr, 4.0)(:hidden, Int64[])
INFO: Loading MNIST...
(:epoch, 0, :trn, (0.09768333f0, 2.869472f0), :tst, (0.0971f0, 2.8795366f0))
(:epoch, 1, :trn, (0.87405f0, 0.8682871912551218), :tst, (0.8737f0, 0.8920107018583927))
(:epoch, 2, :trn, (0.881f0, 0.790548356624777), :tst, (0.8817f0, 0.8375537166115233))
(:epoch, 3, :trn, (0.88521665f0, 0.7357691338922304), :tst, (0.8834f0, 0.8077654484438214))
(:epoch, 4, :trn, (0.889f0, 0.7177930726305428), :tst, (0.8878f0, 0.7949625770097506))
(:epoch, 5, :trn, (0.89346665f0, 0.6850546726297854), :tst, (0.8918f0, 0.7642060693467155))
(:epoch, 6, :trn, (0.88568336f0, 0.8176735448478748), :tst, (0.8815f0, 0.9239837509850817))
(:epoch, 7, :trn, (0.8944167f0, 0.6822875664976291), :tst, (0.8929f0, 0.7671630507019696))
(:epoch, 8, :trn, (0.9009167f0, 0.6277013448980415), :tst, (0.8978f0, 0.7166850000671767))
(:epoch, 9, :trn, (0.89388335f0, 0.674491698188628), :tst, (0.891f0, 0.7775317877832864))
(:epoch, 10, :trn, (0.89738333f0, 0.6708056592583297), :tst, (0.8929f0, 0.7715933695964385))
47.993037 seconds (7.43 M allocations: 2.303 GiB, 1.52% gc time)
```