In [5]:

```
import torch
import torchvision
import numpy as np
import matplotlib.pyplot as plt
import torch.nn as nn
import torch.nn.functional as F


from torchvision.transforms import ToTensor
from torchvision.utils import make_grid
from torch.utils.data.dataloader import DataLoader
from torch.utils.data import random_split
import os
from torchvision.datasets import ImageFolder
import torchvision.transforms as tt
from tqdm import tqdm
from torch.utils.data.dataloader import DataLoader
import torch.nn as nn
import torch.nn.functional as F
import matplotlib.pyplot as plt
%matplotlib inline
```

In [7]:

```
! pip install -q kaggle
from google.colab import files
files.upload()
! mkdir ~/.kaggle
! cp kaggle.json ~/.kaggle/
! chmod 600 ~/.kaggle/kaggle.json
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving kaggle.json to kaggle.json
```

In [8]:

```
! kaggle datasets download grassknoted/asl-alphabet
! unzip asl-alphabet.zip
```

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```

In [11]:

```
cls = os.listdir("asl_alphabet_train/asl_alphabet_train")
len(cls)
img_size = 32*32
aug = tt.Compose(
    [
        tt.Resize(32),
        tt.ToTensor(),
        tt.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))
    ]
)
dataset = ImageFolder("asl_alphabet_train/asl_alphabet_train", aug)

val_size = int(0.10 * len(dataset))
test_size = int(0.10 * len(dataset))
train_size = int((0.8*len(dataset)))

train_ds, val_ds, test_ds = random_split(dataset, [train_size, val_size, test_size])


batch_size = 32
train_dl = DataLoader(train_ds, batch_size, shuffle=True)
val_dl = DataLoader(val_ds, batch_size*2)
test_dl = DataLoader(test_ds, batch_size*2)
```

In [25]:

```
def accuracy(outputs, labels):
    _, preds = torch.max(outputs, dim=1)
    return torch.tensor(torch.sum(preds == labels).item() / len(preds))

class ImageClassificationBase(nn.Module):
    def training_step(self, batch):
        images, labels = batch
        images, labels = images.to(device), labels.to(device)
        out = self(images)                  # Generate predictions
        loss = F.cross_entropy(out, labels) # Calculate loss
        return loss

    def validation_step(self, batch):
        images, labels = batch
        images, labels = images.to(device), labels.to(device)
        out = self(images)                    # Generate predictions
        loss = F.cross_entropy(out, labels)   # Calculate loss
        acc = accuracy(out, labels)           # Calculate accuracy
        return {'val_loss': loss.detach(), 'val_acc': acc}

    def validation_epoch_end(self, outputs):
        bt_loss = [x['val_loss'] for x in outputs]
        ep_loss = torch.stack(bt_loss).mean()   # Combine losses
        bt_accuracy = [x['val_acc'] for x in outputs]
        ep_accuracy = torch.stack(bt_accuracy).mean()      # Combine accuracies
        return {'val_loss': ep_loss.item(), 'val_acc': ep_accuracy.item()}

    def epoch_end(self, epoch, result):
        print(f"Epoch [{epoch, result['lrs'][-1]}]" )
        print(f"last_lr: {result['train_loss']}")
        print(f"train_loss: {result['val_loss']}")
        print(f"Val_Acc: {result['val_acc']}")


def conv_block(in_channels, out_channels, pool=False):
    layers = [nn.Conv2d(in_channels, out_channels, kernel_size=3, padding=1),
              nn.BatchNorm2d(out_channels),
              nn.ReLU(inplace=True)]
    if pool: layers.append(nn.MaxPool2d(2))
    return nn.Sequential(*layers)



class ResNet(ImageClassificationBase):
    def __init__(self, in_channels, num_cls):
        super().__init__()

        self.conv1 = conv_block(in_channels, 64)
        self.conv2 = conv_block(64, 128, pool=True)
        self.res1 = nn.Sequential(conv_block(128, 128), conv_block(128, 128))

        self.conv3 = conv_block(128, 256, pool=True)
        self.conv4 = conv_block(256, 512, pool=True)
        self.res2 = nn.Sequential(conv_block(512, 512), conv_block(512, 512))


        self.classifier = nn.Sequential(nn.MaxPool2d(4),
                                        nn.Flatten(),
                                        nn.Linear(512, num_cls))

    def forward(self, xb):
        xb = xb.to(device)
        out = self.conv1(xb)
        out = self.conv2(out)
        out = self.res1(out) + out
        out = self.conv3(out)
        out = self.conv4(out)
        out = self.res2(out) + out
        out = self.classifier(out)
        return out


def get_default_device():
  if torch.cuda.is_available():
      return torch.device('cuda')
  else:
      return torch.device('cpu')

def to_device(data, device):
  if isinstance(data, (list,tuple)):
      return [to_device(x, device) for x in data]
  return data.to(device, non_blocking=True)


device = get_default_device()
model = to_device(ResNet(3, 29), device)


@torch.no_grad()
def evaluate(model, v_l):
    model.eval()
    outputs = [model.validation_step(batch) for batch in tqdm(v_l)]
    return model.validation_epoch_end(outputs)

def get_lr(optimizer):
    for param_group in optimizer.param_groups:
        return param_group['lr']

def fit_one_cycle(epochs, max_lr, model, t_l, v_l,
                  weight_decay=0, grad_clip=None, opt_func=torch.optim.SGD):
    torch.cuda.empty_cache()
    history = []
    optimizer = opt_func(model.parameters(), max_lr, weight_decay=weight_decay)
    sched = torch.optim.lr_scheduler.OneCycleLR(optimizer, max_lr, epochs=epochs,
                                                steps_per_epoch=len(t_l))

    for epoch in range(epochs):
        model.train()
        train_losses = []
        lrs = []
        for batch in tqdm(t_l):
            loss = model.training_step(batch)
            train_losses.append(loss)
            loss.backward()
            if grad_clip:
                nn.utils.clip_grad_value_(model.parameters(), grad_clip)
            optimizer.step()
            optimizer.zero_grad()
            lrs.append(get_lr(optimizer))
            sched.step()
        result = evaluate(model, v_l)
        result['train_loss'] = torch.stack(train_losses).mean().item()
        result['lrs'] = lrs
        model.epoch_end(epoch, result)
        history.append(result)
    return history
model = to_device(ResNet(3, 29), 'cuda')
history = [evaluate(model, train_dl)]
```

Streaming output truncated to the last 5000 lines.

```
  2%|▏         | 33/2175 [00:01<01:35, 22.49it/s]
  2%|▏         | 36/2175 [00:01<01:34, 22.69it/s]
  2%|▏         | 39/2175 [00:01<01:34, 22.54it/s]
  2%|▏         | 42/2175 [00:01<01:34, 22.69it/s]
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  2%|▏         | 48/2175 [00:02<01:34, 22.62it/s]
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  2%|▏         | 54/2175 [00:02<01:35, 22.12it/s]
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  3%|▎         | 63/2175 [00:02<01:34, 22.36it/s]
  3%|▎         | 66/2175 [00:02<01:33, 22.51it/s]
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  3%|▎         | 72/2175 [00:03<01:32, 22.73it/s]
  3%|▎         | 75/2175 [00:03<01:33, 22.50it/s]
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 11%|█         | 240/2175 [00:10<01:26, 22.24it/s]
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 11%|█▏        | 246/2175 [00:10<01:26, 22.38it/s]
 11%|█▏        | 249/2175 [00:11<01:25, 22.56it/s]
 12%|█▏        | 252/2175 [00:11<01:25, 22.54it/s]
 12%|█▏        | 255/2175 [00:11<01:24, 22.62it/s]
 12%|█▏        | 258/2175 [00:11<01:25, 22.42it/s]
 12%|█▏        | 261/2175 [00:11<01:25, 22.43it/s]
 12%|█▏        | 264/2175 [00:11<01:24, 22.65it/s]
 12%|█▏        | 267/2175 [00:11<01:24, 22.60it/s]
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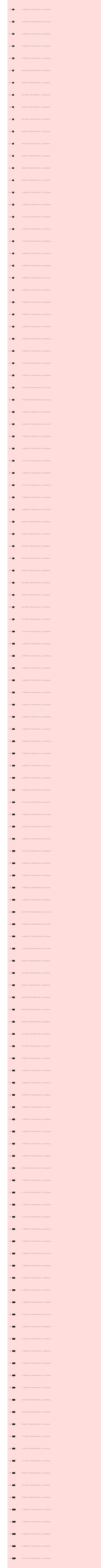
 18%|█▊        | 402/2175 [00:17<01:19, 22.36it/s]
 19%|█▊        | 405/2175 [00:18<01:19, 22.28it/s]
 19%|█▉        | 408/2175 [00:18<01:20, 21.83it/s]
 19%|█▉        | 411/2175 [00:18<01:20, 21.96it/s]
 19%|█▉        | 414/2175 [00:18<01:20, 21.94it/s]
 19%|█▉        | 417/2175 [00:18<01:20, 21.84it/s]
```



```
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 90%|█████████ | 1965/2175 [01:29<00:09, 21.85it/s]
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 91%|█████████ | 1971/2175 [01:29<00:09, 21.38it/s]
 91%|█████████ | 1974/2175 [01:30<00:09, 21.22it/s]
 91%|█████████ | 1977/2175 [01:30<00:09, 21.32it/s]
 91%|█████████ | 1980/2175 [01:30<00:09, 21.27it/s]
 91%|█████████ | 1983/2175 [01:30<00:08, 21.38it/s]
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 91%|█████████▏| 1989/2175 [01:30<00:08, 21.50it/s]
 92%|█████████▏| 1992/2175 [01:30<00:08, 21.20it/s]
 92%|█████████▏| 1995/2175 [01:31<00:08, 21.35it/s]
 92%|█████████▏| 1998/2175 [01:31<00:08, 21.49it/s]
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 92%|█████████▏| 2004/2175 [01:31<00:07, 21.66it/s]
 92%|█████████▏| 2007/2175 [01:31<00:07, 21.60it/s]
 92%|█████████▏| 2010/2175 [01:31<00:07, 21.82it/s]
 93%|█████████▎| 2013/2175 [01:31<00:07, 21.73it/s]
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 94%|█████████▍| 2052/2175 [01:33<00:06, 20.35it/s]
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 95%|█████████▍| 2061/2175 [01:34<00:05, 20.60it/s]
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 97%|█████████▋| 2109/2175 [01:36<00:03, 21.28it/s]
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 98%|█████████▊| 2136/2175 [01:37<00:01, 21.28it/s]
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 99%|█████████▉| 2157/2175 [01:38<00:00, 21.81it/s]
 99%|█████████▉| 2160/2175 [01:38<00:00, 21.84it/s]
 99%|█████████▉| 2163/2175 [01:38<00:00, 21.81it/s]
100%|█████████▉| 2166/2175 [01:39<00:00, 21.51it/s]
100%|█████████▉| 2169/2175 [01:39<00:00, 21.63it/s]
100%|█████████▉| 2172/2175 [01:39<00:00, 21.59it/s]
100%|██████████| 2175/2175 [01:39<00:00, 21.86it/s]
```

In [27]:

```
epochs = 10
max_lr = 0.01
grad_clip = 0.1
weight_decay = 1e-3
opt_func = torch.optim.Adam
history += fit_one_cycle(epochs, max_lr, model, train_dl, val_dl,
                             grad_clip=grad_clip,
                             weight_decay=weight_decay,
                             opt_func=opt_func)
```

```
100%|██████████| 2175/2175 [01:41<00:00, 21.34it/s]
100%|██████████| 136/136 [00:11<00:00, 11.85it/s]
Epoch [(0, 0.002798665629987097)]
last_lr: 0.0677744448184967
train_loss: 0.07700705528259277
Val_Acc: 0.9766544103622437
100%|██████████| 2175/2175 [01:41<00:00, 21.44it/s]
100%|██████████| 136/136 [00:11<00:00, 11.95it/s]
Epoch [(1, 0.007599332722231126)]
last_lr: 0.1365942806005478
train_loss: 0.19132007658481598
Val_Acc: 0.9321920871734619
100%|██████████| 2175/2175 [01:41<00:00, 21.49it/s]
100%|██████████| 136/136 [00:11<00:00, 11.97it/s]
Epoch [(2, 0.01)]
last_lr: 0.1645561009645462
train_loss: 0.18587693572044373
Val_Acc: 0.941130518913269
100%|██████████| 2175/2175 [01:41<00:00, 21.46it/s]
100%|██████████| 136/136 [00:11<00:00, 11.84it/s]
Epoch [(3, 0.009504846320134737)]
last_lr: 0.1532048135995865
train_loss: 0.420965313911438
Val_Acc: 0.8651731014251709
100%|██████████| 2175/2175 [01:41<00:00, 21.40it/s]
100%|██████████| 136/136 [00:11<00:00, 11.98it/s]
Epoch [(4, 0.008117456539497631)]
last_lr: 0.130895733833313
train_loss: 0.1570226401090622
Val_Acc: 0.9456341862678528
100%|██████████| 2175/2175 [01:41<00:00, 21.37it/s]
100%|██████████| 136/136 [00:11<00:00, 12.04it/s]
Epoch [(5, 0.0061126202193628925)]
last_lr: 0.1054430902004242
train_loss: 0.05997134745121002
Val_Acc: 0.9821920990943909
100%|██████████| 2175/2175 [01:46<00:00, 20.34it/s]
100%|██████████| 136/136 [00:11<00:00, 11.51it/s]
Epoch [(6, 0.003887419780637108)]
last_lr: 0.0695546492934227
train_loss: 0.08934744447469711
Val_Acc: 0.9733455777168274
100%|██████████| 2175/2175 [01:44<00:00, 20.81it/s]
100%|██████████| 136/136 [00:11<00:00, 11.92it/s]
Epoch [(7, 0.00188258346050237)]
last_lr: 0.03509935364127159
train_loss: 0.013948079198598862
Val_Acc: 0.995978832244873
100%|██████████| 2175/2175 [01:41<00:00, 21.39it/s]
100%|██████████| 136/136 [00:11<00:00, 11.96it/s]
Epoch [(8, 0.0004951936798652628)]
last_lr: 0.012595287524163723
train_loss: 0.004738333635032177
Val_Acc: 0.9995404481887817
100%|██████████| 2175/2175 [01:41<00:00, 21.46it/s]
100%|██████████| 136/136 [00:11<00:00, 11.90it/s]
Epoch [(9, 4e-08)]
last_lr: 0.004993821028620005
train_loss: 0.0028728663455694914
Val_Acc: 0.999885082244873
```

In [28]:

```
torch.save(model.state_dict(), 'resnet9.pth')
#This model is used in realtime prediction
```

In [30]:

```
model = to_device(ResNet(3, 29), 'cuda')
model.load_state_dict(torch.load('resnet9.pth', map_location='cpu'))
model.eval()
print(evaluate(model, val_dl))
```

```
  0%|          | 0/136 [00:00<?, ?it/s]
  1%|▏         | 2/136 [00:00<00:12, 10.67it/s]
  3%|▎         | 4/136 [00:00<00:15,  8.49it/s]
  4%|▍         | 6/136 [00:00<00:13,  9.64it/s]
  6%|▌         | 8/136 [00:00<00:12, 10.30it/s]
  7%|▋         | 10/136 [00:00<00:11, 10.57it/s]
  9%|▉         | 12/136 [00:01<00:11, 10.65it/s]
 10%|█         | 14/136 [00:01<00:11, 10.73it/s]
 12%|█▏        | 16/136 [00:01<00:10, 10.97it/s]
 13%|█▎        | 18/136 [00:01<00:10, 11.20it/s]
 15%|█▍        | 20/136 [00:01<00:10, 11.21it/s]
 16%|█▌        | 22/136 [00:02<00:10, 11.31it/s]
 18%|█▊        | 24/136 [00:02<00:09, 11.40it/s]
 19%|█▉        | 26/136 [00:02<00:09, 11.39it/s]
 21%|██        | 28/136 [00:02<00:09, 11.29it/s]
 22%|██▏       | 30/136 [00:02<00:09, 11.29it/s]
 24%|██▎       | 32/136 [00:02<00:09, 11.43it/s]
 25%|██▌       | 34/136 [00:03<00:08, 11.40it/s]
 26%|██▋       | 36/136 [00:03<00:08, 11.54it/s]
 28%|██▊       | 38/136 [00:03<00:08, 11.49it/s]
 29%|██▉       | 40/136 [00:03<00:08, 11.32it/s]
 31%|███       | 42/136 [00:03<00:08, 11.44it/s]
 32%|███▏      | 44/136 [00:03<00:07, 11.55it/s]
 34%|███▍      | 46/136 [00:04<00:07, 11.64it/s]
 35%|███▌      | 48/136 [00:04<00:07, 11.58it/s]
 37%|███▋      | 50/136 [00:04<00:07, 11.52it/s]
 38%|███▊      | 52/136 [00:04<00:07, 11.33it/s]
 40%|███▉      | 54/136 [00:04<00:07, 11.17it/s]
 41%|████      | 56/136 [00:05<00:07, 11.22it/s]
 43%|████▎     | 58/136 [00:05<00:06, 11.37it/s]
 44%|████▍     | 60/136 [00:05<00:06, 11.36it/s]
 46%|████▌     | 62/136 [00:05<00:06, 11.34it/s]
 47%|████▋     | 64/136 [00:05<00:06, 11.35it/s]
 49%|████▊     | 66/136 [00:05<00:06, 11.40it/s]
 50%|█████     | 68/136 [00:06<00:05, 11.45it/s]
 51%|█████▏    | 70/136 [00:06<00:05, 11.36it/s]
 53%|█████▎    | 72/136 [00:06<00:05, 11.12it/s]
 54%|█████▍    | 74/136 [00:06<00:05, 11.22it/s]
 56%|█████▌    | 76/136 [00:06<00:05, 11.38it/s]
 57%|█████▋    | 78/136 [00:06<00:05, 11.51it/s]
 59%|█████▉    | 80/136 [00:07<00:04, 11.44it/s]
 60%|██████    | 82/136 [00:07<00:04, 11.32it/s]
 62%|██████▏   | 84/136 [00:07<00:04, 11.23it/s]
 63%|██████▎   | 86/136 [00:07<00:04, 11.37it/s]
 65%|██████▍   | 88/136 [00:07<00:04, 11.03it/s]
 66%|██████▌   | 90/136 [00:08<00:04, 11.16it/s]
 68%|██████▊   | 92/136 [00:08<00:03, 11.18it/s]
 69%|██████▉   | 94/136 [00:08<00:03, 11.37it/s]
 71%|███████   | 96/136 [00:08<00:03, 11.31it/s]
 72%|███████▏  | 98/136 [00:08<00:03, 11.36it/s]
 74%|███████▎  | 100/136 [00:08<00:03, 11.45it/s]
 75%|███████▌  | 102/136 [00:09<00:02, 11.46it/s]
 76%|███████▋  | 104/136 [00:09<00:02, 11.58it/s]
 78%|███████▊  | 106/136 [00:09<00:02, 11.41it/s]
 79%|███████▉  | 108/136 [00:09<00:02, 11.39it/s]
 81%|████████  | 110/136 [00:09<00:02, 11.49it/s]
 82%|████████▏ | 112/136 [00:09<00:02, 11.51it/s]
 84%|████████▍ | 114/136 [00:10<00:01, 11.47it/s]
 85%|████████▌ | 116/136 [00:10<00:01, 11.54it/s]
 87%|████████▋ | 118/136 [00:10<00:01, 11.48it/s]
 88%|████████▊ | 120/136 [00:10<00:01, 11.37it/s]
 90%|████████▉ | 122/136 [00:10<00:01, 11.26it/s]
 91%|█████████ | 124/136 [00:11<00:01, 11.20it/s]
 93%|█████████▎| 126/136 [00:11<00:00, 11.40it/s]
 94%|█████████▍| 128/136 [00:11<00:00, 11.52it/s]
 96%|█████████▌| 130/136 [00:11<00:00, 11.29it/s]
 97%|█████████▋| 132/136 [00:11<00:00, 11.39it/s]
 99%|█████████▊| 134/136 [00:11<00:00, 11.48it/s]
100%|██████████| 136/136 [00:12<00:00, 11.28it/s]
{'val_loss': 0.0028728663455694914, 'val_acc': 0.999885082244873}
```

In [ ]: