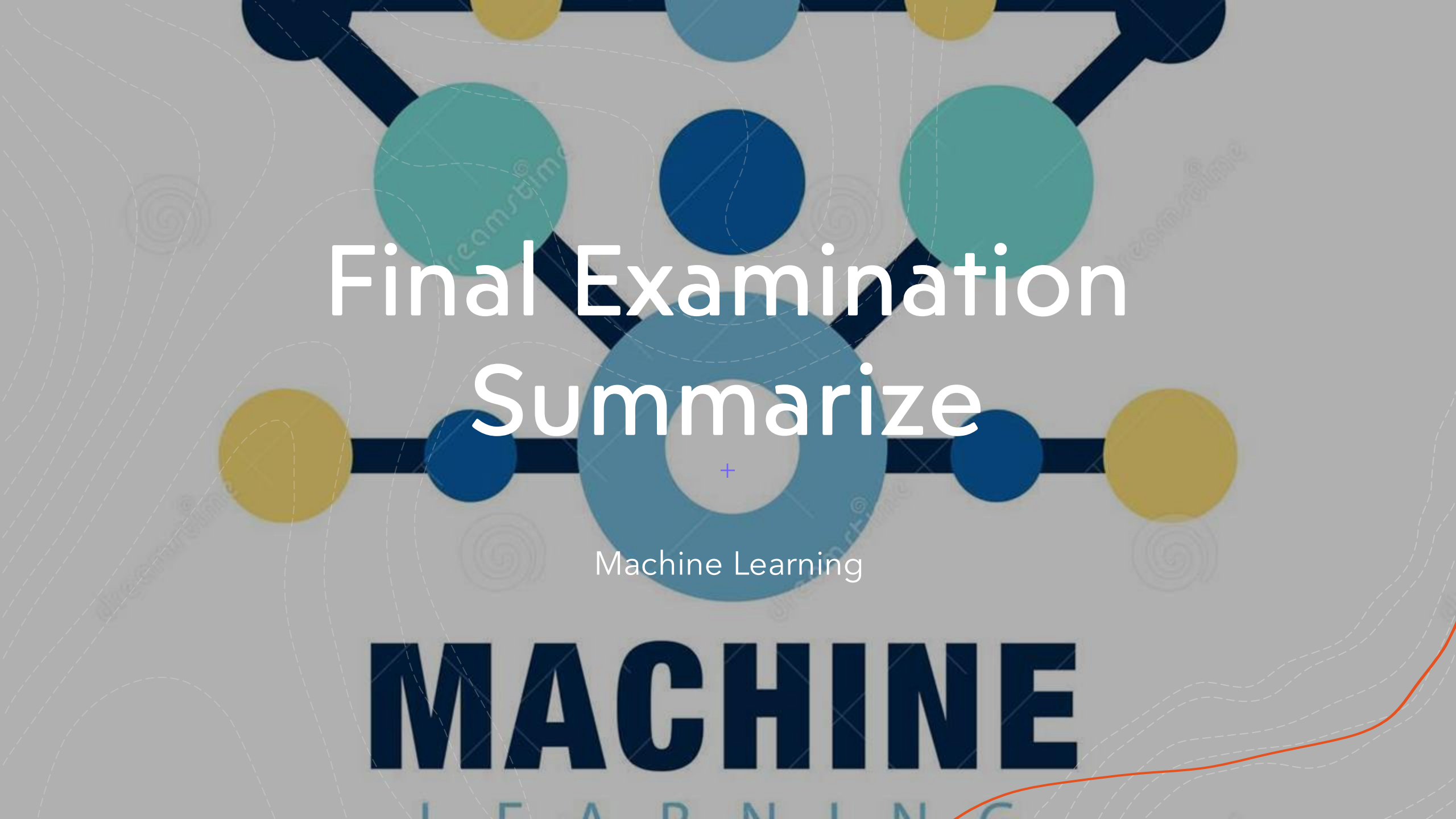
Final Examination Summarize

Machine Learning



CNN with ResNet for MNIST image classification

Residual Neural Network (ResNet) merupakan **salah satu model arsitektur dari CNN**. ResNet merupakan metode yang direkomendasikan untuk melakukan ekstraksi fitur pada citra dalam jumlah yang besar. Metode ini menjaga tingkat saturasi pada citra agar tetap stabil yang berdampak pada meningkatnya tingkat akurasi dan hasil akhir

MNIST DATASET

Dataset MNIST adalah salah satu set data yang paling umum digunakan untuk klasifikasi gambar dan dapat diakses dari berbagai sumber. Faktanya, bahkan Tensorflow dan Keras memungkinkan kita untuk mengimpor dan mendownload dataset MNIST langsung dari API mereka.

MNIST DATASET

In [3]:

```
dataset = MNIST(root='.',
                download=True,
                train=True,
                transform=transforms.ToTensor())

test_dataset = MNIST(root='.',
                train=False,
                transform=transforms.ToTensor())
training_batch = DataLoader(dataset, 100, shuffle=True)


def show_sample_image(training_batch):
    for images, labels in training_batch:
        column = 10
        row = math.ceil(len(labels)/10)
        plt.figure(figsize=(row, column))
        plt.axis('off')
        plt.imshow(make_grid(images, nrow=row).permute((1, 2, 0)))
        #plt.show(block=True)
        #print(labels.reshape(10,10))
        break


show_sample_image(training_batch)
```

```
Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz to ./MNIST/raw/train-images-idx3-ubyte.gz
  0%|          | 0/9912422 [00:00<?, ?it/s]
Extracting ./MNIST/raw/train-images-idx3-ubyte.gz to ./MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz to ./MNIST/raw/train-labels-idx1-ubyte.gz
  0%|          | 0/28881 [00:00<?, ?it/s]
Extracting ./MNIST/raw/train-labels-idx1-ubyte.gz to ./MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz to ./MNIST/raw/t10k-images-idx3-ubyte.gz
  0%|          | 0/1648877 [00:00<?, ?it/s]
Extracting ./MNIST/raw/t10k-images-idx3-ubyte.gz to ./MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz to ./MNIST/raw/t10k-labels-idx1-ubyte.gz
  0%|          | 0/4542 [00:00<?, ?it/s]
Extracting ./MNIST/raw/t10k-labels-idx1-ubyte.gz to ./MNIST/raw
```

MNIST DATASET

Kemudian akan mendapatkan visualisasi greyscale dari kode RGB seperti gambar disamping ini.

CNN-Resnet Model

In [5]:

```
class ResNet9(nn.Module):
    def __init__(self):
        super().__init__()
        self.conv1 = nn.Sequential(
            nn.Conv2d(1, 64, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(64),
            nn.ReLU(),
            nn.MaxPool2d(2, 2)
        )
        self.conv2 = nn.Sequential(
            nn.Conv2d(64, 128, kernel_size=3, stride=1, padding=2),
            nn.BatchNorm2d(128),
            nn.ReLU(),
            nn.MaxPool2d(2, 2)
        )
        self.res1 = nn.Sequential(
            nn.Conv2d(128, 256, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(256),
            nn.ReLU(),
            nn.Conv2d(256, 128, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(128),
            nn.ReLU(),
        )
        self.conv3 = nn.Sequential(
            nn.Conv2d(128, 256, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(256),
            nn.ReLU(),
            nn.MaxPool2d(2, 2)
        )
        self.conv4 = nn.Sequential(
            nn.Conv2d(256, 512, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.MaxPool2d(2, 2)
        )
        self.res2 = nn.Sequential(
            nn.Conv2d(512, 1024, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(1024),
            nn.ReLU(),
            nn.Conv2d(1024, 512, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(512),
            nn.ReLU(),
        )
        self.classifier = nn.Sequential(
            nn.MaxPool2d(2, 2),
            nn.Flatten(),
            nn.Linear(512, 10)
        )


    def forward(self, x):
        out = self.conv1(x)
        out = self.conv2(out)
        out1 = self.res1(out) + out
        out1 = self.conv3(out1)
        out1 = self.conv4(out1)
        out2 = self.res2(out1) + out1
        out2 = self.classifier(out2)
        return out2
def parameter(model):
    para = 0
    for i in model.parameters():
        para += i.numel()
    return para
model = ResNet9().to(device)
parameter(model)
```

Training

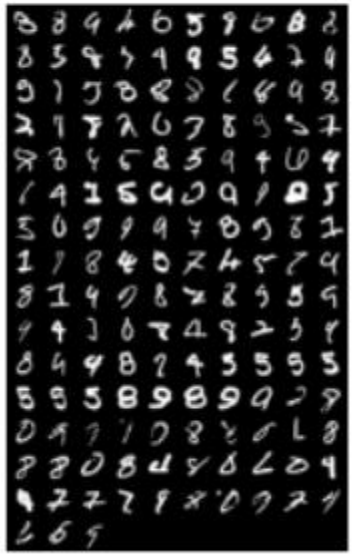
In [ ]:

```python
def accuracy(outputs, labels):
    with t.no_grad():
        com = F.softmax(outputs, dim=1)
        max_prob, pred_label = t.max(com, dim=1)
        item = pred_label == labels
        return t.sum(item).item() / len(labels)


def loss_batch(model, loss_fn, images, given_labels, opt=None):
    ll = len(images)
    loss = loss_fn(model(images), given_labels)
    if opt is not None:
        loss.backward()
        opt.step()
        opt.zero_grad()
    metric = accuracy(model(images), given_labels)
    return loss.item(), ll, metric


def evaluate(model, loss_fn, batch):
    total_loss = 0.
    total_item = 0.
    total_metric = 0.
    with t.no_grad():
        for images, given_labels in batch:
            images = images.to(device)
            given_labels = given_labels.to(device)
            results = loss_batch(model, loss_fn, images, given_labels)
            losses, items, metrics = results
            total_loss += losses * items
            total_item += items
            total_metric += metrics * items
        avg_loss = total_loss / total_item
        avg_metric = total_metric / total_item
    return avg_loss, total_item, avg_metric
```

```python
def fit(total_epochs, model, loss_fn, opt, train_dl, test_data):
    # training of the model
    t.cuda.empty_cache()
    for epoch in range(total_epochs):
        for image, given_label in train_dl:
            image = image.to(device)
            given_label = given_label.to(device)
            loss_batch(model, loss_fn, image, given_label, opt)
        # checking the model on the test set
        result = evaluate(model, loss_fn, test_data)
        loss,_,metric = result
        print(f"Epoch [{epoch+1}]: test loss = {loss:.4f}, test accuracy = {metric*100:.2f}%")
from timeit import default_timer as timer
start = timer()
loss_fn = F.cross_entropy
print("Training: phase 1")
opt = t.optim.Adam(model.parameters(), lr=1e-3, weight_decay=0.001)
fit(2, model, loss_fn, opt, training_batch, testing_batch)
print("Training: phase 2")
opt = t.optim.Adam(model.parameters(), lr=1e-4, weight_decay=0.001)
fit(10, model, loss_fn, opt, training_batch, testing_batch)
print("Training: phase 3")
opt = t.optim.Adam(model.parameters(), lr=1e-5, weight_decay=0.001)
fit(8, model, loss_fn, opt, training_batch, testing_batch)
end = timer()
print(f"Training time = {end-start} seconds")
```

Models

Out[10]: <matplotlib.image.AxesImage at 0x7f19943dc4d0>



In [8]:
```
t.save(model.state_dict(), 'MNIST_ResNet.pth')
```

In [9]:
```
with t.no_grad():
    for images, given_labels in testing_batch:
            images = images.to(device)
            given_labels = given_labels.to(device)
            outputs = model(images)
            com = F.softmax(outputs, dim=1)
            max_prob, pred_label = t.max(com, dim=1)
            item = pred_label == given_labels
            print(item)
```

```
tensor([True, True, True,  ..., True, True, True])
```

In [10]:
```
with t.no_grad():
    missed_images = []
    predicted_labels = []
    correct_labels = []
    for images, given_labels in testing_batch:
      for i in range(10000):
        if item[i] == False:
          missed_images.append(images[i])
          predicted_labels.append(pred_label[i].item())
          correct_labels.append(given_labels[i].item())
# Let's now see all the missed images from the test set
column = 4
row = 10
plt.figure(figsize=(row, column))
plt.axis('off')
plt.imshow(make_grid(missed_images, nrow=row).permute((1, 2, 0)))
```

Out[10]: <matplotlib.image.AxesImage at 0x7f19943dc4d0>

LABELS

In [11]:
```
print("Predicted Labels:")
print(predicted_labels[:10])
print(predicted_labels[10:20])
print(predicted_labels[20:30])
print(predicted_labels[30:40])
```

```
Predicted Labels:
[8, 2, 4, 2, 0, 3, 9, 0, 0, 2]
[2, 3, 9, 4, 9, 9, 3, 6, 2, 4]
[2, 1, 2, 0, 2, 2, 6, 6, 4, 9]
[7, 9, 7, 7, 6, 7, 6, 8, 2, 2]
```

In [12]:
```
print("Correct Labels:")
print(correct_labels[:10])
print(correct_labels[10:20])
print(correct_labels[20:30])
print(correct_labels[30:40])
```

```
Correct Labels:
[3, 8, 9, 4, 6, 5, 8, 6, 8, 8]
[8, 5, 8, 7, 4, 8, 5, 4, 7, 9]
[9, 7, 5, 8, 8, 8, 1, 8, 9, 8]
[2, 7, 8, 2, 0, 3, 8, 9, 5, 7]
```

Thank You

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