In [1]:

```python
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.activations import relu, linear, sigmoid

#Load data from MNIST dataset
(X_train,y_train),(X_test,y_test) = tf.keras.datasets.mnist.load_data()

#Normalize the data
X_train,X_test = X_train/255.0, X_test/255.0

#reshape the data
X_train = X_train.reshape(-1,28*28)
X_test = X_test.reshape(-1,28*28)
print(X_train.shape)
print(X_test.shape)


#Define model
tf.random.set_seed(1234)
model=Sequential([
    tf.keras.Input(shape=(784,)),
    Dense(units=25, activation='relu', name = 'L1'),
    Dense(units=15, activation='relu', name = 'L2'),
    Dense(units=10, activation='linear', name = 'L3')
], name = "my_model")
model.summary()

#Compile model
model.compile(
    loss = tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True), #Def
    optimizer = tf.keras.optimizers.Adam(learning_rate=0.001), #Define optimizer
    metrics=['accuracy']
)

#Fit the model to the training sets
history=model.fit(
    X_train,
    y_train,
    epochs=10)
```

```
(60000, 784)
(10000, 784)
```

Model: "my_model"

```
┃ Layer (type)                ┃ Output Shape           ┃       Param #
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━
│ L1 (Dense)                  │ (None, 25)             │        19,625
├─────────────────────────────┼────────────────────────┼──────────────
│ L2 (Dense)                  │ (None, 15)             │           390
├─────────────────────────────┼────────────────────────┼──────────────
│ L3 (Dense)                  │ (None, 10)             │           160
└─────────────────────────────┴────────────────────────┴──────────────
```

```
Total params: 20,175 (78.81 KB)
```

```
Trainable params: 20,175 (78.81 KB)

Non-trainable params: 0 (0.00 B)

Epoch 1/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 9s 3ms/step - accuracy: 0.7794 - loss: 0.7350
Epoch 2/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9340 - loss: 0.2262
Epoch 3/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 9s 2ms/step - accuracy: 0.9482 - loss: 0.1800
Epoch 4/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9547 - loss: 0.1538
Epoch 5/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9599 - loss: 0.1364
Epoch 6/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 9s 5ms/step - accuracy: 0.9632 - loss: 0.1233
Epoch 7/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 11s 6ms/step - accuracy: 0.9662 - loss: 0.1126
Epoch 8/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 10s 5ms/step - accuracy: 0.9689 - loss: 0.1048
Epoch 9/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 10s 5ms/step - accuracy: 0.9709 - loss: 0.0978
Epoch 10/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9729 - loss: 0.0913
```

In [2]:

```python
#prediction
prediction = model.predict(X_test[0].reshape(1,784))
prediction_p = tf.nn.softmax(prediction)
yhat = np.argmax(prediction_p)
print(yhat)
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 156ms/step
7
```

In [5]:

```python
import warnings
warnings.simplefilter(action='ignore', category=FutureWarning)

# Assume images are 20x20 pixels in dataset X
m, n = X_test.shape
y = y_test
X = X_test
# Set up plot
fig, axes = plt.subplots(8, 8, figsize=(5, 5))
fig.tight_layout(pad=0.13, rect=[0, 0.03, 1, 0.91])  # [left, bottom, right, top

# Loop through each subplot and display random images with predictions
for i, ax in enumerate(axes.flat):
    # Select random indices
    random_index = np.random.randint(m)

    # Select and reshape the random image for display
    X_random_reshaped = X[random_index].reshape((28, 28)).T  # Transpose for cor
    ax.imshow(X_random_reshaped, cmap='gray')

    # Predict using the model (reshape to match model's expected input shape)
    prediction = model.predict(X[random_index].reshape(1, 784))
    prediction_p = tf.nn.softmax(prediction)
    yhat = np.argmax(prediction_p)

    # Display the label above the image
    ax.set_title(f"{y[random_index]},{yhat}", fontsize=10)
    ax.set_axis_off()
```

```
fig.suptitle("Label, yhat", fontsize=14)
plt.show()

def display_errors(model, X, y):
    # Make predictions on the entire dataset
    predictions = model.predict(X, verbose=0)
    predictions_p = tf.nn.softmax(predictions)
    y_pred = np.argmax(predictions_p, axis=1)

    # Count the number of errors
    errors = np.sum(y_pred != y)

    return errors

# Call the function and display the result
print(f"{display_errors(model, X, y)} errors out of {len(X)} images")
```

```
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 78ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
```

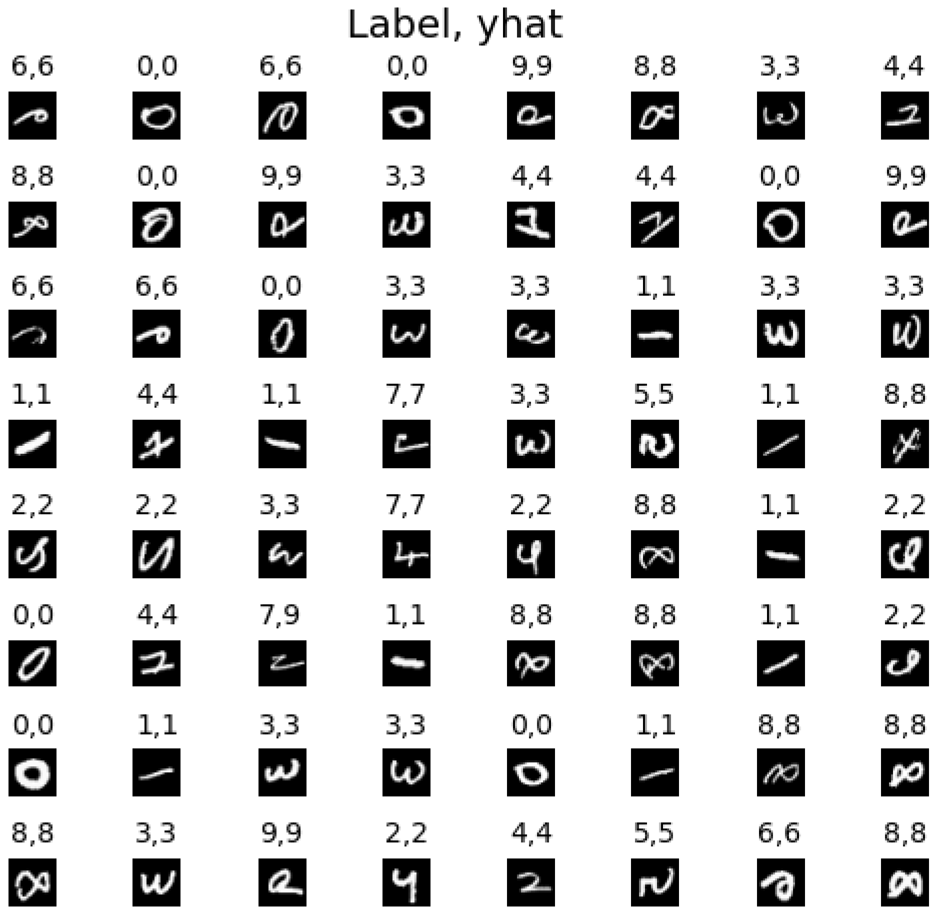

```
434 errors out of 10000 images
```

In [ ]: