In [3]:
```
import tensorflow as tf
from tensorflow import keras
from keras.models import Sequential
from keras.layers import Activation, Dense, Flatten, BatchNormalization, Conv2D, MaxPool2D, Dropout
from keras.optimizers import Adam, SGD
from keras.metrics import categorical_crossentropy
from keras.preprocessing.image import ImageDataGenerator

import warnings
import numpy as np
import cv2
from keras.callbacks import ReduceLROnPlateau
from keras.callbacks import ModelCheckpoint, EarlyStopping
warnings.simplefilter(action='ignore', category=FutureWarning)


background = None
accumulated_weight = 0.5

#Creating the dimensions for the ROI...
ROI_top = 100
ROI_bottom = 300
ROI_right = 150
ROI_left = 350
```

In [4]:
```
train_path = r'/home/anonimouz/Documents/SignLanguage/gesture/train'
test_path = r'/home/anonimouz/Documents/SignLanguage/gesture/test'
train_batches = ImageDataGenerator(preprocessing_function=tf.keras.applications.vgg16.preprocess_input).flow_from_di
test_batches = ImageDataGenerator(preprocessing_function=tf.keras.applications.vgg16.preprocess_input).flow_from_dir
```

```
Found 31101 images belonging to 26 classes.
Found 730 images belonging to 26 classes.
```

In [17]:
```
import matplotlib.pyplot as plt
imgs, labels = next(train_batches)
#Plotting the images...
def plotImages(images_arr):
    fig, axes = plt.subplots(1, 10, figsize=(30,20))
    axes = axes.flatten()
    for img, ax in zip( images_arr, axes):
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        ax.imshow(img)
        ax.axis('off')
    plt.tight_layout()
    plt.show()
plotImages(imgs)
print(imgs.shape)
print(labels)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```

```
print(labels)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
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Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```

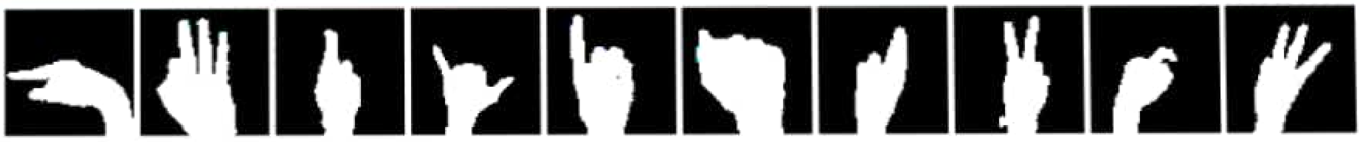

```
(10, 64, 64, 3)
[[0. 0. 0. 0. 0. 0. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
  0. 0.]
 [0. 0. 0. 0. 0. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
  0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1. 0. 0. 0. 0. 0. 0.
  0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
  1. 0.]
 [0. 0. 0. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
  0. 0.]
 [1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
  0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1. 0. 0. 0.
  0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1. 0. 0.
  0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1.
  0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1. 0.
  0. 0.]]
```

In [6]:

```
model = Sequential()
model.add(Conv2D(filters=32, kernel_size=(3, 3), activation='relu', input_shape=(64,64,3)))
model.add(MaxPool2D(pool_size=(2, 2), strides=2))
model.add(Conv2D(filters=64, kernel_size=(3, 3), activation='relu', padding = 'same'))
model.add(MaxPool2D(pool_size=(2, 2), strides=2))
model.add(Conv2D(filters=128, kernel_size=(3, 3), activation='relu', padding = 'valid'))
model.add(MaxPool2D(pool_size=(2, 2), strides=2))
model.add(Flatten())
model.add(Dense(64,activation ="relu"))
model.add(Dense(128,activation ="relu"))
#model.add(Dropout(0.2))
model.add(Dense(128,activation ="relu"))
#model.add(Dropout(0.3))
model.add(Dense(26,activation ="softmax"))
```

In [7]:
```
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_3 (Conv2D)           (None, 62, 62, 32)        896

 max_pooling2d_3 (MaxPooling  (None, 31, 31, 32)       0
 2D)

 conv2d_4 (Conv2D)           (None, 31, 31, 64)        18496

 max_pooling2d_4 (MaxPooling  (None, 15, 15, 64)       0
 2D)

 conv2d_5 (Conv2D)           (None, 13, 13, 128)       73856

 max_pooling2d_5 (MaxPooling  (None, 6, 6, 128)        0
 2D)

 flatten_1 (Flatten)         (None, 4608)              0

 dense_4 (Dense)             (None, 64)                294976

 dense_5 (Dense)             (None, 128)               8320

 dense_6 (Dense)             (None, 128)               16512

 dense_7 (Dense)             (None, 26)                3354

=================================================================
Total params: 416,410
Trainable params: 416,410
Non-trainable params: 0
_________________________________________________________________
```

In [8]:
```
model.compile(optimizer=SGD(learning_rate=0.001), loss='categorical_crossentropy', metrics=['accuracy'])
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=1, min_lr=0.0005)
early_stop = EarlyStopping(monitor='val_loss', min_delta=0, patience=2, verbose=0, mode='auto')


model.compile(optimizer=Adam(learning_rate=0.001), loss='categorical_crossentropy', metrics=['accuracy'])
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=1, min_lr=0.0001)
early_stop = EarlyStopping(monitor='val_loss', min_delta=0, patience=2, verbose=0, mode='auto')
```

In [9]:
```
history2 = model.fit(train_batches, epochs=10, callbacks=[reduce_lr, early_stop],  validation_data = test_batches)
```

```
Epoch 1/10
3111/3111 [==============================] - 76s 24ms/step - loss: 0.1676 - accuracy: 0.9638 - val_loss: 0.0613 - v
al_accuracy: 0.9863 - lr: 0.0010
Epoch 2/10
3111/3111 [==============================] - 73s 24ms/step - loss: 0.0426 - accuracy: 0.9929 - val_loss: 1.6384e-05
- val accuracy: 1.0000 - lr: 0.0010
```

```
Non-trainable params: 0
_________________________________________________________________
```

In [8]:
```
model.compile(optimizer=SGD(learning_rate=0.001), loss='categorical_crossentropy', metrics=['accuracy'])
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=1, min_lr=0.0005)
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early_stop = EarlyStopping(monitor='val_loss', min_delta=0, patience=2, verbose=0, mode='auto')
```

In [9]:
```
history2 = model.fit(train_batches, epochs=10, callbacks=[reduce_lr, early_stop],  validation_data = test_batches)
```

```
Epoch 1/10
3111/3111 [==============================] - 76s 24ms/step - loss: 0.1676 - accuracy: 0.9638 - val_loss: 0.0613 - v
al_accuracy: 0.9863 - lr: 0.0010
Epoch 2/10
3111/3111 [==============================] - 73s 24ms/step - loss: 0.0426 - accuracy: 0.9929 - val_loss: 1.6384e-05
- val_accuracy: 1.0000 - lr: 0.0010
Epoch 3/10
3111/3111 [==============================] - 76s 24ms/step - loss: 0.0218 - accuracy: 0.9966 - val_loss: 1.1261e-06
- val_accuracy: 1.0000 - lr: 0.0010
Epoch 4/10
3111/3111 [==============================] - 75s 24ms/step - loss: 6.0457e-05 - accuracy: 1.0000 - val_loss: 0.0061
- val_accuracy: 0.9959 - lr: 2.0000e-04
Epoch 5/10
3111/3111 [==============================] - 73s 23ms/step - loss: 3.1256e-04 - accuracy: 0.9999 - val_loss: 1.2166
e-07 - val_accuracy: 1.0000 - lr: 1.0000e-04
Epoch 6/10
3111/3111 [==============================] - 73s 23ms/step - loss: 3.4253e-07 - accuracy: 1.0000 - val_loss: 4.2295
e-08 - val_accuracy: 1.0000 - lr: 1.0000e-04
Epoch 7/10
3111/3111 [==============================] - 74s 24ms/step - loss: 1.0593e-07 - accuracy: 1.0000 - val_loss: 9.9613
e-09 - val_accuracy: 1.0000 - lr: 1.0000e-04
Epoch 8/10
3111/3111 [==============================] - 72s 23ms/step - loss: 2.5110e-08 - accuracy: 1.0000 - val_loss: 9.7980
e-10 - val_accuracy: 1.0000 - lr: 1.0000e-04
Epoch 9/10
3111/3111 [==============================] - 73s 23ms/step - loss: 6.1941e-09 - accuracy: 1.0000 - val_loss: 0.0000
e+00 - val_accuracy: 1.0000 - lr: 1.0000e-04
Epoch 10/10
3111/3111 [==============================] - 75s 24ms/step - loss: 1.7900e-09 - accuracy: 1.0000 - val_loss: 0.0000
e+00 - val_accuracy: 1.0000 - lr: 1.0000e-04
```

In [10]:
```
imgs, labels = next(test_batches)
```

In [11]:
```
scores = model.evaluate(imgs, labels, verbose=0)
print(f'{model.metrics_names[0]} of {scores[0]}; {model.metrics_names[1]} of {scores[1]*100}%')
```

```
loss of 0.0; accuracy of 100.0%
```

In [12]:
```
model.save('ASLmodel.h5')
```

In [10]:
```
imgs, labels = next(test_batches)
```

In [11]:
```
scores = model.evaluate(imgs, labels, verbose=0)
print(f'{model.metrics_names[0]} of {scores[0]}; {model.metrics_names[1]} of {scores[1]*100}%')
```

```
loss of 0.0; accuracy of 100.0%
```

In [12]:
```
model.save('ASLmodel.h5')
```