

## Лабораторна робота № 8

### ДОСЛІДЖЕННЯ МЕТОДІВ НЕКОНТРОЛЬОВАНОГО НАВЧАННЯ

**Тема:** «Ресурси Keras. TensorFlow. Навчання лінійної регресії».

**Мета:** Дослідження ресурсу Keras і TensorFlow. Застосування TensorFlow.

**Час виконання:** 4 години.

**Навчальні питання:** 1). Структура і ресурси Keras і TensorFlow;

**Завдання:** Використовуючи засоби TensorFlow, реалізувати код наведений нижче та дослідити структуру розрахункового алгоритму

**Лістинг:**

```
import tensorflow as tf
import numpy as np

n_samples, batch_size, num_steps = 1000, 100, 20000

X_data = np.random.uniform(0, 1, (n_samples, 1)).astype(np.float32)
y_data = 2 * X_data + 1 + np.random.normal(0, 0.2, (n_samples, 1)).astype(np.float32)

k = tf.Variable(tf.random.normal((1, 1), stddev=0.01, dtype=tf.float32),
name='slope')
b = tf.Variable(tf.zeros((1,)), dtype=tf.float32, name='bias')

def model(X):
    return tf.matmul(X, k) + b

def loss_fn(y_true, y_pred):
    return tf.reduce_sum(tf.square(y_true - y_pred))

optimizer = tf.optimizers.SGD(learning_rate=0.001)

for step in range(num_steps):
    indices = np.random.choice(n_samples, batch_size)
    X_batch, y_batch = X_data[indices], y_data[indices]

    with tf.GradientTape() as tape:
        y_pred = model(X_batch)
        loss = loss_fn(y_batch, y_pred)

    gradients = tape.gradient(loss, [k, b])
```

```
optimizer.apply_gradients(zip(gradients, [k, b]))

if (step + 1) % 100 == 0:
    print(f"Step {step + 1}: loss = {loss.numpy()}, k = {k.numpy()[0][0]}, b = {b.numpy()[0]}")
```

## Результат виконання програми:

```
Step 100: loss = 4.898872375488281, k = 1.6655287742614746, b = 1.1810929775238037
Step 200: loss = 3.5534467697143555, k = 1.884434461593628, b = 1.053037166595459
Step 300: loss = 4.144540786743164, k = 1.958434820175171, b = 1.023499846458435
Step 400: loss = 4.009382247924805, k = 1.9675260782241821, b = 1.019525170326233
Step 500: loss = 3.8174617290496826, k = 1.9810749292373657, b = 1.0201493501663208
Step 600: loss = 4.120734214782715, k = 1.9733269214630127, b = 1.0027281045913696
Step 700: loss = 3.6669411659240723, k = 1.959229588508606, b = 1.0157355070114136
Step 800: loss = 4.117527961730957, k = 1.9717533588409424, b = 1.0176613330841064
Step 900: loss = 4.318188667297363, k = 1.9741486310958862, b = 1.0069580078125
Step 1000: loss = 4.763640403747559, k = 1.97063410282135, b = 1.0064911842346191
Step 1100: loss = 4.868382930755615, k = 1.9698209762573242, b = 1.0021605491638184
Step 1200: loss = 4.046787738800049, k = 1.9651426076889038, b = 1.0114070177078247
Step 1300: loss = 3.337864398956299, k = 1.9721113443374634, b = 1.0114747285842896
Step 1400: loss = 3.601832866668701, k = 1.9676988124847412, b = 1.0091474056243896
Step 1500: loss = 3.205580711364746, k = 1.9669761657714844, b = 1.0048574209213257
Step 1600: loss = 3.433501958847046, k = 1.9736788272857666, b = 1.0142120122909546
Step 1700: loss = 3.0527002811431885, k = 1.9842084646224976, b = 1.013353705406189
Step 1800: loss = 2.9872021675109863, k = 1.9725910425186157, b = 1.003955602645874
Step 1900: loss = 4.337249755859375, k = 1.9602805376052856, b = 1.0154097080230713
Step 2000: loss = 3.411498785018921, k = 1.9723035097122192, b = 1.0097013711929321
Step 2100: loss = 3.7498416900634766, k = 1.9663100242614746, b =
0.9941371083259583
Step 2200: loss = 4.0263671875, k = 1.9678725004196167, b = 1.0078926086425781
Step 2300: loss = 3.2496719360351562, k = 1.979198932647705, b = 0.9972905516624451
Step 2400: loss = 3.5494887828826904, k = 1.9598604440689087, b =
1.0039622783660889
Step 2500: loss = 4.2261061668396, k = 1.9636719226837158, b = 1.013051152229309
Step 2600: loss = 4.340031623840332, k = 1.9630870819091797, b = 1.0096194744110107
Step 2700: loss = 3.6735687255859375, k = 1.9795544147491455, b =
1.0086710453033447
Step 2800: loss = 3.2956702709198, k = 1.9829903841018677, b = 1.013709306716919
Step 2900: loss = 4.749293327331543, k = 1.970729112625122, b = 1.0075430870056152
Step 3000: loss = 3.618594169616699, k = 1.9741671085357666, b = 1.027133822441101
Step 3100: loss = 4.798295974731445, k = 1.9827929735183716, b = 1.0099846124649048
Step 3200: loss = 4.229772567749023, k = 1.9680496454238892, b = 1.0080519914627075
Step 3300: loss = 3.2182443141937256, k = 1.9696305990219116, b =
1.0109223127365112
Step 3400: loss = 3.179377555847168, k = 1.9675058126449585, b = 1.0162607431411743
```

Step 3500: loss = 3.2661075592041016, k = 1.976791262626648, b = 1.0233010053634644  
Step 3600: loss = 4.277674674987793, k = 1.9686583280563354, b = 1.0062904357910156  
Step 3700: loss = 3.7240371704101562, k = 1.9751914739608765, b =  
1.0230776071548462  
Step 3800: loss = 3.7834458351135254, k = 1.964159369468689, b = 1.0004258155822754  
Step 3900: loss = 4.260171890258789, k = 1.976789951324463, b = 1.0116472244262695  
Step 4000: loss = 4.020287036895752, k = 1.9819296598434448, b = 1.0055334568023682  
Step 4100: loss = 3.4604029655456543, k = 1.9724094867706299, b =  
1.0081936120986938  
Step 4200: loss = 4.483557701111084, k = 1.9637302160263062, b = 1.0046401023864746  
Step 4300: loss = 4.7992472648620605, k = 1.9691789150238037, b =  
1.0064080953598022  
Step 4400: loss = 3.7544970512390137, k = 1.9709326028823853, b =  
1.0103336572647095  
Step 4500: loss = 3.7498135566711426, k = 1.9782947301864624, b =  
1.0055758953094482  
Step 4600: loss = 4.0262908935546875, k = 1.9749401807785034, b =  
1.0171191692352295  
Step 4700: loss = 4.086070537567139, k = 1.966138243675232, b = 1.011053442955017  
Step 4800: loss = 4.728546142578125, k = 1.9767673015594482, b = 1.0284212827682495  
Step 4900: loss = 3.869098663330078, k = 1.964727520942688, b = 1.0007377862930298  
Step 5000: loss = 4.342294216156006, k = 1.9670960903167725, b = 1.0026715993881226  
Step 5100: loss = 3.7162539958953857, k = 1.9790394306182861, b =  
1.0149798393249512  
Step 5200: loss = 3.8047661781311035, k = 1.9716156721115112, b =  
1.0016671419143677  
Step 5300: loss = 3.0041377544403076, k = 1.9724810123443604, b =  
1.0046966075897217  
Step 5400: loss = 3.3400626182556152, k = 1.973141074180603, b = 1.0083931684494019  
Step 5500: loss = 3.989090919494629, k = 1.9759936332702637, b = 1.0185037851333618  
Step 5600: loss = 5.116261005401611, k = 1.9765846729278564, b = 1.0133272409439087  
Step 5700: loss = 3.484431743621826, k = 1.9721349477767944, b = 0.9952573180198669  
Step 5800: loss = 3.526357650756836, k = 1.9735519886016846, b = 1.0035055875778198  
Step 5900: loss = 3.9541800022125244, k = 1.9733768701553345, b =  
1.0071635246276855  
Step 6000: loss = 3.5875203609466553, k = 1.9839961528778076, b =  
1.0050455331802368  
Step 6100: loss = 4.387168884277344, k = 1.9761910438537598, b = 1.0157091617584229  
Step 6200: loss = 3.357595443725586, k = 1.9779741764068604, b = 1.010136604309082  
Step 6300: loss = 4.162792205810547, k = 1.9738829135894775, b = 1.0163218975067139  
Step 6400: loss = 3.6097676753997803, k = 1.971108078956604, b = 1.0084809064865112  
Step 6500: loss = 3.535837411880493, k = 1.976167917251587, b = 1.0157651901245117  
Step 6600: loss = 3.8413400650024414, k = 1.973731279373169, b = 1.0018962621688843  
Step 6700: loss = 3.8149771690368652, k = 1.9822055101394653, b =  
1.0182042121887207  
Step 6800: loss = 3.2265045642852783, k = 1.978752851486206, b = 1.015756607055664  
Step 6900: loss = 3.5666756629943848, k = 1.976282000541687, b = 1.0267013311386108

Step 7000: loss = 3.142455577850342, k = 1.968199372291565, b = 1.0166974067687988  
Step 7100: loss = 5.087096214294434, k = 1.9736967086791992, b = 1.0128453969955444  
Step 7200: loss = 3.5293850898742676, k = 1.9802916049957275, b = 1.014165997505188  
Step 7300: loss = 3.6588611602783203, k = 1.9630740880966187, b = 1.010134220123291  
Step 7400: loss = 3.272749900817871, k = 1.9671484231948853, b = 1.007313847541809  
Step 7500: loss = 3.8147268295288086, k = 1.9631260633468628, b =  
1.0188267230987549  
Step 7600: loss = 3.2411458492279053, k = 1.9667460918426514, b =  
1.0114294290542603  
Step 7700: loss = 3.264955520629883, k = 1.9605940580368042, b = 1.001706600189209  
Step 7800: loss = 3.9394612312316895, k = 1.9681047201156616, b =  
1.0116856098175049  
Step 7900: loss = 3.6465325355529785, k = 1.9670896530151367, b = 1.000363826751709  
Step 8000: loss = 3.414771795272827, k = 1.9779129028320312, b = 1.0173149108886719  
Step 8100: loss = 3.5172712802886963, k = 1.9744311571121216, b =  
1.0068426132202148  
Step 8200: loss = 5.111926078796387, k = 1.962646722793579, b = 1.009519338607788  
Step 8300: loss = 3.8004231452941895, k = 1.9534268379211426, b =  
1.0067970752716064  
Step 8400: loss = 2.6090757846832275, k = 1.968264102935791, b = 1.0063625574111938  
Step 8500: loss = 3.917219400405884, k = 1.9703385829925537, b = 1.011596918106079  
Step 8600: loss = 4.038376808166504, k = 1.96517014503479, b = 1.004279613494873  
Step 8700: loss = 4.33978796005249, k = 1.9612717628479004, b = 1.0204099416732788  
Step 8800: loss = 4.229976654052734, k = 1.9613134860992432, b = 1.017690658569336  
Step 8900: loss = 4.148449897766113, k = 1.976478099822998, b = 1.0160541534423828  
Step 9000: loss = 3.6485257148742676, k = 1.9720629453659058, b =  
0.9996368288993835  
Step 9100: loss = 3.7358949184417725, k = 1.9722645282745361, b =  
1.0057984590530396  
Step 9200: loss = 3.628528594970703, k = 1.9795506000518799, b = 1.013056993484497  
Step 9300: loss = 4.724516868591309, k = 1.980535864830017, b = 1.0229761600494385  
Step 9400: loss = 3.3218281269073486, k = 1.9777494668960571, b =  
1.0222705602645874  
Step 9500: loss = 3.5185227394104004, k = 1.9617348909378052, b =  
1.0133296251296997  
Step 9600: loss = 2.6898975372314453, k = 1.9657975435256958, b =  
1.0178546905517578  
Step 9700: loss = 5.073501110076904, k = 1.9588626623153687, b = 0.9970932602882385  
Step 9800: loss = 4.361847400665283, k = 1.9601778984069824, b = 1.0115152597427368  
Step 9900: loss = 4.3882317543029785, k = 1.968765377998352, b = 1.0089786052703857  
Step 10000: loss = 4.508426666259766, k = 1.9634519815444946, b =  
1.0101068019866943  
Step 10100: loss = 3.5664124488830566, k = 1.9715155363082886, b =  
1.0073426961898804  
Step 10200: loss = 3.2806832790374756, k = 1.9796507358551025, b =  
1.0029221773147583

Step 10300: loss = 3.6250319480895996, k = 1.9831771850585938, b = 1.0075509548187256  
Step 10400: loss = 3.9313902854919434, k = 1.969269037246704, b = 1.0048084259033203  
Step 10500: loss = 4.252989292144775, k = 1.9676846265792847, b = 1.003826379776001  
Step 10600: loss = 3.78338623046875, k = 1.9771637916564941, b = 1.010387897491455  
Step 10700: loss = 4.222966194152832, k = 1.9643340110778809, b = 1.0169970989227295  
Step 10800: loss = 3.8619344234466553, k = 1.9669134616851807, b = 1.0083520412445068  
Step 10900: loss = 3.825472116470337, k = 1.9777908325195312, b = 1.0080490112304688  
Step 11000: loss = 3.801457166671753, k = 1.9733552932739258, b = 1.0072216987609863  
Step 11100: loss = 4.138334274291992, k = 1.9617401361465454, b = 1.005225419998169  
Step 11200: loss = 3.765022039413452, k = 1.9782050848007202, b = 1.0143489837646484  
Step 11300: loss = 3.498124122619629, k = 1.9706929922103882, b = 1.0028091669082642  
Step 11400: loss = 4.80710506439209, k = 1.9763705730438232, b = 1.015133261680603  
Step 11500: loss = 3.552790403366089, k = 1.9605727195739746, b = 1.015408992767334  
Step 11600: loss = 4.23867654800415, k = 1.965535283088684, b = 1.009891152381897  
Step 11700: loss = 3.5654385089874268, k = 1.9708476066589355, b = 1.014722228050232  
Step 11800: loss = 4.211459159851074, k = 1.9642212390899658, b = 1.0173975229263306  
Step 11900: loss = 4.118932723999023, k = 1.973819613456726, b = 1.0139251947402954  
Step 12000: loss = 4.119545936584473, k = 1.9703186750411987, b = 1.0058393478393555  
Step 12100: loss = 3.624326229095459, k = 1.9803308248519897, b = 1.0054383277893066  
Step 12200: loss = 4.511939525604248, k = 1.9752177000045776, b = 1.0097886323928833  
Step 12300: loss = 4.024202346801758, k = 1.9825999736785889, b = 1.0150152444839478  
Step 12400: loss = 4.293946266174316, k = 1.9754164218902588, b = 1.0092798471450806  
Step 12500: loss = 4.556232452392578, k = 1.9665530920028687, b = 1.0053948163986206  
Step 12600: loss = 3.7098519802093506, k = 1.9679677486419678, b = 1.0136183500289917  
Step 12700: loss = 4.511789798736572, k = 1.9571990966796875, b = 1.017409324645996  
Step 12800: loss = 4.500247001647949, k = 1.9599435329437256, b = 1.0126992464065552  
Step 12900: loss = 3.9805116653442383, k = 1.9675815105438232, b = 1.0207606554031372

Step 13000: loss = 5.183078765869141, k = 1.9640783071517944, b = 1.0090025663375854  
Step 13100: loss = 4.399827480316162, k = 1.9592732191085815, b = 1.003570556640625  
Step 13200: loss = 3.7452993392944336, k = 1.9666717052459717, b = 1.002137303352356  
Step 13300: loss = 3.6576037406921387, k = 1.9669063091278076, b = 1.0039950609207153  
Step 13400: loss = 3.9905753135681152, k = 1.9730291366577148, b = 1.0074087381362915  
Step 13500: loss = 3.130283832550049, k = 1.9709646701812744, b = 1.0182477235794067  
Step 13600: loss = 3.829458713531494, k = 1.9762625694274902, b = 1.0117065906524658  
Step 13700: loss = 3.344001293182373, k = 1.9705040454864502, b = 1.0087794065475464  
Step 13800: loss = 3.1155786514282227, k = 1.9572715759277344, b = 1.0038648843765259  
Step 13900: loss = 3.206312894821167, k = 1.9588392972946167, b = 1.0089625120162964  
Step 14000: loss = 4.038290977478027, k = 1.9696444272994995, b = 1.0117411613464355  
Step 14100: loss = 4.2062506675720215, k = 1.963011384010315, b = 1.0152446031570435  
Step 14200: loss = 3.8322389125823975, k = 1.9672380685806274, b = 1.0045591592788696  
Step 14300: loss = 3.245833158493042, k = 1.9723014831542969, b = 1.0074397325515747  
Step 14400: loss = 3.6930150985717773, k = 1.9656704664230347, b = 1.0143132209777832  
Step 14500: loss = 3.5617942810058594, k = 1.9773801565170288, b = 1.0187406539916992  
Step 14600: loss = 3.664848804473877, k = 1.9723252058029175, b = 1.0083231925964355  
Step 14700: loss = 4.659425735473633, k = 1.9629017114639282, b = 1.0042309761047363  
Step 14800: loss = 3.289721965789795, k = 1.9631050825119019, b = 1.0127900838851929  
Step 14900: loss = 3.1662962436676025, k = 1.9645898342132568, b = 1.0064324140548706  
Step 15000: loss = 3.494962215423584, k = 1.9743980169296265, b = 1.0114766359329224  
Step 15100: loss = 3.7064340114593506, k = 1.9696391820907593, b = 1.0212076902389526  
Step 15200: loss = 5.144984245300293, k = 1.9664252996444702, b = 1.0196897983551025  
Step 15300: loss = 3.389711380004883, k = 1.9775804281234741, b = 1.0121046304702759



Step 15400: loss = 4.096715450286865, k = 1.973744511604309, b = 1.0064895153045654  
Step 15500: loss = 3.65083646774292, k = 1.9646276235580444, b = 0.9924828410148621  
Step 15600: loss = 3.605433702468872, k = 1.9853858947753906, b = 1.0124387741088867  
Step 15700: loss = 3.071763038635254, k = 1.9722235202789307, b = 0.9992247819900513  
Step 15800: loss = 3.6432137489318848, k = 1.9699492454528809, b = 1.0037444829940796  
Step 15900: loss = 4.391132831573486, k = 1.9631942510604858, b = 0.9994782209396362  
Step 16000: loss = 3.617820978164673, k = 1.9687931537628174, b = 0.9988073706626892  
Step 16100: loss = 3.887418746948242, k = 1.9610956907272339, b = 1.0108041763305664  
Step 16200: loss = 3.902444362640381, k = 1.9753254652023315, b = 1.022417426109314  
Step 16300: loss = 3.465846300125122, k = 1.969099998474121, b = 1.0059223175048828  
Step 16400: loss = 4.438494682312012, k = 1.9761993885040283, b = 1.0176972150802612  
Step 16500: loss = 3.846503496170044, k = 1.967605710029602, b = 1.0088679790496826  
Step 16600: loss = 3.56553316116333, k = 1.9744435548782349, b = 1.0192749500274658  
Step 16700: loss = 3.9624085426330566, k = 1.9759999513626099, b = 1.0109221935272217  
Step 16800: loss = 4.1082611083984375, k = 1.9788777828216553, b = 1.0005924701690674  
Step 16900: loss = 3.7771189212799072, k = 1.9638962745666504, b = 1.009408950805664  
Step 17000: loss = 4.8575568199157715, k = 1.9727147817611694, b = 1.021796464920044  
Step 17100: loss = 4.720210552215576, k = 1.9734143018722534, b = 0.9969187378883362  
Step 17200: loss = 4.25330924987793, k = 1.972122311592102, b = 0.9926960468292236  
Step 17300: loss = 3.805349349975586, k = 1.9683797359466553, b = 1.0026296377182007  
Step 17400: loss = 3.4853339195251465, k = 1.9791820049285889, b = 1.0123904943466187  
Step 17500: loss = 3.2702207565307617, k = 1.9769923686981201, b = 1.0063459873199463  
Step 17600: loss = 3.9925057888031006, k = 1.9628371000289917, b = 1.0257775783538818  
Step 17700: loss = 3.6031675338745117, k = 1.967487096786499, b = 1.0097970962524414  
Step 17800: loss = 3.5078725814819336, k = 1.9728015661239624, b = 1.006840705871582  
Step 17900: loss = 3.581613779067993, k = 1.9733953475952148, b = 1.0000306367874146  
Step 18000: loss = 3.683408260345459, k = 1.9823400974273682, b = 1.0035392045974731

Step 18100: loss = 5.435223579406738, k = 1.9709370136260986, b = 1.0105687379837036  
Step 18200: loss = 3.9636197090148926, k = 1.9737846851348877, b = 1.0142862796783447  
Step 18300: loss = 5.320982933044434, k = 1.9825732707977295, b = 0.9972396492958069  
Step 18400: loss = 3.4354867935180664, k = 1.9637666940689087, b = 1.0097315311431885  
Step 18500: loss = 3.336838722229004, k = 1.9728901386260986, b = 1.0203375816345215  
Step 18600: loss = 3.820042371749878, k = 1.9714444875717163, b = 1.0030945539474487  
Step 18700: loss = 3.99991512298584, k = 1.9695942401885986, b = 1.0158971548080444  
Step 18800: loss = 4.406998634338379, k = 1.968580961227417, b = 1.0183920860290527  
Step 18900: loss = 3.8851799964904785, k = 1.970962405204773, b = 0.9973068237304688  
Step 19000: loss = 3.8490242958068848, k = 1.9696271419525146, b = 1.014391541481018  
Step 19100: loss = 2.823883533477783, k = 1.959985375404358, b = 1.0124605894088745  
Step 19200: loss = 3.4650983810424805, k = 1.9682714939117432, b = 1.022718906402588  
Step 19300: loss = 3.93399715423584, k = 1.9771002531051636, b = 1.018842101097107  
Step 19400: loss = 3.8974997997283936, k = 1.9718308448791504, b = 1.008461356163025  
Step 19500: loss = 4.500627517700195, k = 1.966008186340332, b = 1.0129027366638184  
Step 19600: loss = 3.517922878265381, k = 1.9709786176681519, b = 1.0051778554916382  
Step 19700: loss = 3.6980204582214355, k = 1.9703168869018555, b = 1.0005027055740356  
Step 19800: loss = 4.378661632537842, k = 1.9787777662277222, b = 1.0070139169692993  
Step 19900: loss = 3.5948710441589355, k = 1.9724572896957397, b = 1.0094444751739502  
Step 20000: loss = 3.3178844451904297, k = 1.982090711593628, b = 1.0060852766036987

[Done] exited with code=0 in 33.492 seconds



Також застосуємо інший підхід до виконання

А саме явно використаєм Keras:

Лістинг:

```
import tensorflow as tf
import numpy as np

n_samples = 1000
X_data = np.random.uniform(0, 1, (n_samples, 1)).astype(np.float32)
y_data = 2 * X_data + 1 + np.random.normal(0, 0.2, (n_samples, 1)).astype(np.float32)

model = tf.keras.Sequential([
    tf.keras.layers.Dense(1, input_dim=1, use_bias=True,
        kernel_initializer='random_normal', bias_initializer='zeros')
])

model.compile(optimizer=tf.optimizers.SGD(learning_rate=0.001),
    loss='mean_squared_error')

model.fit(X_data, y_data, epochs=20000, batch_size=100, verbose=100)

print(f"Final parameters: k = {model.weights[0].numpy()[0][0]}, b = {model.weights[1].numpy()}")
```

**Результат виконання програми (його кінцеві рядки):**

```
Epoch 19991/20000
Epoch 19992/20000
Epoch 19993/20000
Epoch 19994/20000
Epoch 19995/20000
Epoch 19996/20000
Epoch 19997/20000
Epoch 19998/20000
Epoch 19999/20000
Epoch 20000/20000
Final parameters: k = 2.0055251121520996, b = [1.0041242]

[Done] exited with code=0 in 111.768 seconds
```

GIT: [https://github.com/Alhim616/AI\\_Labs\\_Yanushevych](https://github.com/Alhim616/AI_Labs_Yanushevych)