Package 'DeepPINCS'

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Type Package

Title Protein Interactions and Networks with Compounds based on Sequences using Deep Learning

Description

The identification of novel compound-protein interaction (CPI) is important in drug discovery. Revealing unknown compound-protein interactions is useful to design a new drug for a target protein by screening candidate compounds. The accurate CPI prediction assists in effective drug discovery process. To identify potential CPI effectively, prediction methods based on machine learning and deep learning have been developed. Data for sequences are provided as discrete symbolic data. In the data, compounds are represented as SMILES (simplified molecular-input line-entry system) strings and proteins are sequences in which the characters are amino acids. The outcome is defined as a variable that indicates how strong two molecules interact with each other or whether there is an interaction between them. In this package, a deep-learning based model that takes only sequence information of both compounds and proteins as input and the outcome as output is used to predict CPI. The model is implemented by using compound and protein encoders with useful features. The CPI model also supports other modeling tasks, including protein-protein interaction (PPI), chemical-chemical interaction (CCI), or single compounds and proteins. Although the model is designed for proteins, DNA and RNA can be used if they are represented as sequences.

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Contents

antiviral_drug 2
cpi_model 3
encoder_in_out 8
example_bioassay 10
example_cci 11
example_chem 11
example_cpi 12
example_pd 12
example_ppi 13
example_prot 13
get_canonical_smiles 14
get_fingerprint 15
get_graph_structure_node_feature 16
get_seq_encode_pad 17
metric_concordance_index 18
metric_f1_score 19
multiple_sampling_generator 20
SARS_CoV2_3CL_Protease 21
seq_check 22
seq_preprocessing 23

Index **25**

`antiviral_drug` *List of antiviral drugs with SMILES strings*

Description

81 antiviral drugs with SMILES strings

Usage

```
antiviral_drug
```

Value

SMILES string

Author(s)

Dongmin Jung

Source

Huang, K., Fu, T., Glass, L. M., Zitnik, M., Xiao, C., & Sun, J. (2020). DeepPurpose: A Deep Learning Library for Drug-Target Interaction Prediction. Bioinformatics.

`cpi_model` *Deep learning model fitting and prediction for compound-protein interactions*

Description

The model for compound-protein interactions (CPI) takes the pair of SMILES strings of compounds and amino acid sequences (one letter amino acid code) of proteins as input. They are fed into the compound and protein encoders, respectively, and then these encoders are concatenated. Due to the combination of compound and protein encoders, there are many kinds of CPI models. However, the graph neural network such as the graph concolutional network (GCN) is only available for compounds. We need to select one of types of compounds. For graph and fingerprint, the SMILES sequences are not used for encoders, because the information of graph or fingerprint is extracted from the SMILES sequenes and then it is fed into encoders. For sequence, the unigram is used as default, but the n-gram is available only for proteins. Since the CPI model needs some arguments of encoders, we may have to match the names of such arguments.

Usage

```
fit_cpi(smiles = NULL, AAseq = NULL, outcome,
        convert_canonical_smiles = TRUE,
        compound_type = NULL, compound_max_atoms,
        compound_length_seq, protein_length_seq,
        compound_embedding_dim, protein_embedding_dim,
        protein_ngram_max = 1, protein_ngram_min = 1,
        smiles_val = NULL, AAseq_val = NULL, outcome_val = NULL,
        net_args = list(
            compound,
            compound_args,
            protein,
            protein_args,
            fc_units = c(1),
            fc_activation = c("linear"), ...),
        net_names = list(
            name_compound_max_atoms = NULL,
```

```
            name_compound_feature_dim = NULL,
            name_compound_fingerprint_size = NULL,
            name_compound_embedding_layer = NULL,
            name_compound_length_seq = NULL,
            name_compound_num_tokens = NULL,
            name_compound_embedding_dim = NULL,
            name_protein_length_seq = NULL,
            name_protein_num_tokens = NULL,
            name_protein_embedding_dim = NULL),
        preprocessor_only = FALSE,
        preprocessing = list(
            outcome = NULL,
            outcome_val = NULL,
            convert_canonical_smiles = NULL,
            canonical_smiles = NULL,
            compound_type = NULL,
            compound_max_atoms = NULL,
            compound_A_pad = NULL,
            compound_X_pad = NULL,
            compound_A_pad_val = NULL,
            compound_X_pad_val = NULL,
            compound_fingerprint = NULL,
            compound_fingerprint_val = NULL,
            smiles_encode_pad = NULL,
            smiles_val_encode_pad = NULL,
            compound_lenc = NULL,
            compound_length_seq = NULL,
            compound_num_tokens = NULL,
            compound_embedding_dim = NULL,
            AAseq_encode_pad = NULL,
            AAseq_val_encode_pad = NULL,
            protein_lenc = NULL,
            protein_length_seq = NULL,
            protein_num_tokens = NULL,
            protein_embedding_dim = NULL,
            protein_ngram_max = NULL,
            protein_ngram_min = NULL),
        batch_size, use_generator = FALSE,
        validation_split = 0, ...)

predict_cpi(modelRes, smiles = NULL, AAseq = NULL,
            preprocessing = list(
                canonical_smiles = NULL,
                compound_A_pad = NULL,
                compound_X_pad = NULL,
                compound_fingerprint = NULL,
                smiles_encode_pad = NULL,
                AAseq_encode_pad = NULL),
```

```
              use_generator = FALSE,
              batch_size = NULL)
```

Arguments

smiles	SMILES strings, each column for the element of a pair (default: NULL)
AAseq	amino acid sequences, each column for the element of a pair (default: NULL)
outcome	a variable that indicates how strong two molecules interact with each other or whether there is an interaction between them
convert_canonical_smiles	SMILES strings are converted to canonical SMILES strings if TRUE (default: TRUE)
compound_type	"graph", "fingerprint" or "sequence"
compound_max_atoms	maximum number of atoms for compounds
compound_length_seq	length of compound sequence
protein_length_seq	length of protein sequence
compound_embedding_dim	dimension of the dense embedding for compounds
protein_embedding_dim	dimension of the dense embedding for proteins
protein_ngram_max	maximum size of an n-gram for protein sequences (default: 1)
protein_ngram_min	minimum size of an n-gram for protein sequences (default: 1)
smiles_val	SMILES strings for validation (default: NULL)
AAseq_val	amino acid sequences for validation (default: NULL)
outcome_val	outcome for validation (default: NULL)
net_args	list of arguments for compound and protein encoder networks and for fully connected layer • compound : encoder network for compounds • compound_args : arguments of compound encoder • protein : encoder network for proteins • protein_args : arguments of protein encoder • fc_units : dimensionality of the output space in the fully connected layer (default: 1) • fc_activation : activation of the fully connected layer (default: "linear") • ... : arguments of "keras::compile" but for object
net_names	list of names of arguments used in both the CPI model and encoder networks, names are set to NULL as default • name_compound_max_atoms : corresponding name for the maximum number of atoms in the compound encoder, "max_atoms" if NULL

- name_compound_feature_dim : corresponding name for the dimension of node features in the compound encoder, "feature_dim" if NULL
- name_compound_fingerprint_size : corresponding name for the length of a fingerprint in the compound encoder, "fingerprint_size" if NULL
- name_compound_embedding_layer : corresponding name for the use of the embedding layer in the compound encoder, "embedding_layer" if NULL
- name_compound_length_seq : corresponding name for the length of sequences in the compound encoder, "length_seq" if NULL
- name_compound_num_tokens : corresponding name for the total number of distinct strings in the compound encoder, "num_tokens" if NULL
- name_compound_embedding_dim : corresponding name for dimension of the dense embedding in the compound encoder, "embedding_dim" if NULL
- name_protein_length_seq : corresponding name for the length of sequences in the protein encoder, "length_seq" if NULL
- name_protein_num_tokens : corresponding name for the total number of distinct strings in the protein encoder, "num_tokens" if NULL
- name_protein_embedding_dim : corresponding name for dimension of the dense embedding in the protein encoder, "embedding_dim" if NULL

`preprocessor_only`
: model is not fitted after preprocessing if TRUE (default: FALSE)

`preprocessing`
: list of preprocessed results for "fit_cpi" or "predict_cpi", they are set to NULL as default

- outcome : outcome variable
- outcome_val : outcome variable for validation
- convert_canonical_smiles : canonical representation used for preprocessing if TRUE
- canonical_smiles : canonical representation of SMILES
- compound_type : "graph", "fingerprint" or "sequence"
- compound_max_atoms : maximum number of atoms for compounds
- compound_A_pad : padded or turncated adjacency matrix of compounds
- compound_X_pad : padded or turncated node features of compounds
- compound_A_pad_val : padded or turncated adjacency matrix for validation
- compound_X_pad_val : padded or turncated node features for validation
- compound_fingerprint : fingerprint of compounds
- compound_fingerprint_val : fingerprint for validation
- smiles_encode_pad : encoded SMILES sequence which is padded or truncated
- smiles_val_encode_pad : encoded SMILES sequence for validation
- compound_lenc : encoded labels for characters of SMILES strings
- compound_length_seq : length of compound sequence
- compound_num_tokens : total number of characters of compounds
- compound_embedding_dim : dimension of the dense embedding for compounds

- AAseq_encode_pad : encoded amino acid sequence which is padded or truncated
- AAseq_val_encode_pad : encoded amino acid sequence for validation
- protein_lenc : encoded labels for characters of amino acid sequenes
- protein_length_seq : length of protein sequence
- protein_num_tokens : total number of characters of proteins
- protein_embedding_dim : dimension of the dense embedding for proteins
- protein_ngram_max : maximum size of an n-gram for protein sequences
- protein_ngram_min : minimum size of an n-gram for protein sequences
- removed_smiles : index for removed smiles while checking
- removed_AAseq : index for removed AAseq while checking
- removed_smiles_val : index for removed smiles of validation
- removed_AAseq_val : index for removed AAseq of validation

`batch_size` batch size

`use_generator` use data generator if TRUE (default: FALSE)

`validation_split` proportion of validation data, it is ignored when there is a validation set (default: 0)

`modelRes` result of the "fit_cpi"

`...` additional parameters for the "keras::fit" or "keras::fit_generator"

Value

model

Author(s)

Dongmin Jung

See Also

keras::compile, keras::fit, keras::fit_generator, keras::layer_dense, keras::keras_model, purrr::pluck, webchem::is.smiles

Examples

```
if (keras::is_keras_available() & reticulate::py_available()) {
    compound_max_atoms <- 50
    protein_embedding_dim <- 16
    protein_length_seq <- 100
    gcn_cnn_cpi <- fit_cpi(
        smiles = example_cpi[1:100, 1],
        AAseq = example_cpi[1:100, 2],
        outcome = example_cpi[1:100, 3],
        compound_type = "graph",
        compound_max_atoms = compound_max_atoms,
        protein_length_seq = protein_length_seq,
```

```
    protein_embedding_dim = protein_embedding_dim,
    net_args = list(
        compound = "gcn_in_out",
        compound_args = list(
            gcn_units = c(128, 64),
            gcn_activation = c("relu", "relu"),
            fc_units = c(10),
            fc_activation = c("relu")),
        protein = "cnn_in_out",
        protein_args = list(
            cnn_filters = c(32),
            cnn_kernel_size = c(3),
            cnn_activation = c("relu"),
            fc_units = c(10),
            fc_activation = c("relu")),
        fc_units = c(1),
        fc_activation = c("sigmoid"),
        loss = "binary_crossentropy",
        optimizer = keras::optimizer_adam(),
        metrics = "accuracy"),
    epochs = 2, batch_size = 16)
pred <- predict_cpi(gcn_cnn_cpi, example_cpi[101:110, 1], example_cpi[101:110, 2])

gcn_cnn_cpi2 <- fit_cpi(
    preprocessing = gcn_cnn_cpi$preprocessing,
    net_args = list(
        compound = "gcn_in_out",
        compound_args = list(
            gcn_units = c(128, 64),
            gcn_activation = c("relu", "relu"),
            fc_units = c(10),
            fc_activation = c("relu")),
        protein = "cnn_in_out",
        protein_args = list(
            cnn_filters = c(32),
            cnn_kernel_size = c(3),
            cnn_activation = c("relu"),
            fc_units = c(10),
            fc_activation = c("relu")),
        fc_units = c(1),
        fc_activation = c("sigmoid"),
        loss = "binary_crossentropy",
        optimizer = keras::optimizer_adam(),
        metrics = "accuracy"),
    epochs = 2, batch_size = 16)
pred <- predict_cpi(gcn_cnn_cpi2, preprocessing = pred$preprocessing)
}
```

---

encoder_in_out *Input and output tensors of encoders*

Description

The graph convolutional network (GCN), recurrent neural network (RNN), convolutional neural network (CNN), and multilayer perceptron (MLP) are used as encoders. The last layer of the encoders is the fully connected layer. The units and activation can be vectors and the length of the vectors represents the number of layers.

Usage

```
gcn_in_out(max_atoms, feature_dim, gcn_units, gcn_activation,
    fc_units, fc_activation)

rnn_in_out(length_seq, fingerprint_size, embedding_layer = TRUE,
    num_tokens, embedding_dim, rnn_type, rnn_bidirectional,
    rnn_units, rnn_activation, fc_units, fc_activation)

cnn_in_out(length_seq, fingerprint_size, embedding_layer = TRUE,
    num_tokens, embedding_dim, cnn_filters, cnn_kernel_size, cnn_activation,
    fc_units, fc_activation)

mlp_in_out(length_seq, fingerprint_size, embedding_layer = TRUE,
    num_tokens, embedding_dim, fc_units, fc_activation)
```

Arguments

max_atoms	maximum number of atoms for gcn
feature_dim	dimension of atom features for gcn
gcn_units	dimensionality of the output space in the gcn layer
gcn_activation	activation of the gcn layer
fingerprint_size	the length of a fingerprint
embedding_layer	use the embedding layer if TRUE (default: TRUE)
embedding_dim	a non-negative integer for dimension of the dense embedding
length_seq	length of input sequences
num_tokens	total number of distinct strings
cnn_filters	dimensionality of the output space in the cnn layer
cnn_kernel_size	length of the 1D convolution window in the cnn layer
cnn_activation	activation of the cnn layer
rnn_type	"lstm" or "gru"
rnn_bidirectional	use the bidirectional wrapper for rnn if TRUE
rnn_units	dimensionality of the output space in the rnn layer
rnn_activation	activation of the rnn layer
fc_units	dimensionality of the output space in the fully connected layer
fc_activation	activation of the fully connected layer

Value

input and output tensors of encoders

Author(s)

Dongmin Jung

See Also

keras::layer_activation, keras::bidirectional, keras::layer_conv_1d, keras::layer_dense, keras::layer_dot, keras::layer_embedding, keras::layer_global_average_pooling_1d, keras::layer_input, keras::layer_lstm, keras::layer_gru, keras::layer_flatten

Examples

```
if (keras::is_keras_available() & reticulate::py_available()) {
    gcn_in_out(max_atoms = 50,
        feature_dim = 50,
        gcn_units = c(128, 64),
        gcn_activation = c("relu", "relu"),
        fc_units = c(10),
        fc_activation = c("relu"))
}
```

---

example_bioassay *Example Data for PubChem AID1706 bioassay*

Description

This is a compound-protein interaction data set retrieved from PubChem AID1706 bioassay. The data is balanced and a randomly selected subset of a dataset of size 5000. The label is 1 if the score is greater than or equal to 15, otherwise it is 0.

Usage

```
example_bioassay
```

Value

compound-protein interaction data

Author(s)

Dongmin Jung

Source

Huang, K., Fu, T., Glass, L. M., Zitnik, M., Xiao, C., & Sun, J. (2020). DeepPurpose: A Deep Learning Library for Drug-Target Interaction Prediction. Bioinformatics.

example_cci *Example Data for Chemical-Chemical Interactions*

Description

The data is a randomly selected subset with size 1000 for chemical-chemical interactions. The two SMILES strings are for compound pairs and the label is for their interactions.

Usage

```
example_cci
```

Value

chemical-chemical interaction data

Author(s)

Dongmin Jung

Source

Huang, K., Xiao, C., Hoang, T., Glass, L., & Sun, J. (2020). CASTER: Predicting drug interactions with chemical substructure representation. AAAI.

example_chem *Example Data for Compounds*

Description

Blood-Brain-Barrier (BBB) is a permeability barrier for maintaining homeostasis of Central Nervous System (CNS). The data is a curated compound dataset with known BBB permeability. Compounds are divided into two groups according to whether the brain to blood concentration ratio was greater or less than 0.1. The row name labels each row with the compound name.

Usage

```
example_chem
```

Value

compound data

Author(s)

Dongmin Jung

Source

Gao, Z., Chen, Y., Cai, X., & Xu, R. (2017). Predict drug permeability to blood-brain-barrier from clinical phenotypes: drug side effects and drug indications. Bioinformatics, 33(6), 901-908.

`example_cpi` *Example Data for Compound-Protein Interactions*

Description

The data consist of compound-protein pairs and their interactions of human. The SMILES and amino acid sequences are used for compounds and proteins, respectively. The binary outcome label is whether or not they interact each other.

Usage

```
example_cpi
```

Value

compound-protein interaction data

Author(s)

Dongmin Jung

Source

Tsubaki, M., Tomii, K., & Sese, J. (2019). Compound-protein interaction prediction with end-to-end learning of neural networks for graphs and sequences. Bioinformatics, 35(2), 309-318.

`example_pd` *Example Data for Primer-Dimer*

Description

This is a primer-primer interaction data set with size 319. The two sequences are for primer pairs and the label is for their interactions.

Usage

```
example_pd
```

Value

primer sequences and dimer formation data

Author(s)

Dongmin Jung

Source

Johnston, A. D., Lu, J., Ru, K. L., Korbie, D., & Trau, M. (2019). PrimerROC: accurate condition-independent dimer prediction using ROC analysis. Scientific reports.

---

example_ppi *Example Data for Protein-Protein Interactions*

Description

The data is a randomly selected subset with size 5000 for protein-protein interactions of yeast. The two amino acid sequences are for protein pairs and the label is for their interactions.

Usage

```
example_ppi
```

Value

protein-protein interaction data

Author(s)

Dongmin Jung

Source

Chen, M., et al. (2019). Multifaceted protein-protein interaction prediction based on siamese residual rcnn. Bioinformatics, 35(14), i305-i314.

---

example_prot *Example Data for Proteins*

Description

This is a protein data set retrieved from Research Collaboratory for Structural Bioinformatics (RCSB) Protein Data Bank (PDB).The data consist of amino acid sequences with three classes. The row name labels each row with the PDB identification code.

Usage

```
example_prot
```

Value

protein data

Author(s)

Dongmin Jung

Source

Research Collaboratory for Structural Bioinformatics (RCSB) Protein Data Bank (PDB) and https://www.kaggle.com/shahir/p
data-set

`get_canonical_smiles` *Convert SMILES strings to canonical SMILES strings*

Description

There may be many different ways to construct the SMILES string for a given molecule. A canonical representation is a unique ordering of the atoms for a given molecular graph.

Usage

```
get_canonical_smiles(smiles)
```

Arguments

`smiles`	SMILES strings

Value

canonical representation of SMILES

Author(s)

Dongmin Jung

References

Leach, A. R., & Gillet, V. J. (2007). An introduction to chemoinformatics. Springer.

See Also

rcdk::parse.smile, rcdk::get.smiles, rcdk::smiles.flavors

Examples

```
get_canonical_smiles(example_cpi[1, 1])
```

`get_fingerprint` *Molecular fingerprint of compounds from SMILES strings*

Description

A molecular fingerprint is a way of encoding the structural features of a molecule. The most common type of fingerprint is a sequence of ones and zeros. Fingerprints are special kinds of descriptors that characterize a molecule and its properties as a binary bit vector that represents the presence or absence of particular substructure in the molecule. For such a fingerprint, the Chemistry Development Kit (CDK) is used as a cheminformatics tool.

Usage

```
get_fingerprint(smiles, ...)
```

Arguments

`smiles`	SMILES strings
`...`	arguments for "rcdk::get.fingerprint" but for molecule

Value

a fingerprint of a compound

Author(s)

Dongmin Jung

References

Balakin, K. V. (2009). Pharmaceutical data mining: approaches and applications for drug discovery. Wiley.

See Also

rcdk::get.fingerprint, rcdk::parse.smiles

Examples

```
get_fingerprint(example_cpi[1, 1])
```

`get_graph_structure_node_feature` *Graph structure and node features from SMILES strings*

Description

In molecular graph representations, nodes represent atoms and edges represent bonds. For molecular features, the Chemistry Development Kit (CDK) is used as a cheminformatics tool. The degree of an atom in the graph representation and the atomic symbol and implicit hydrogen count for an atom are used as molecular features.

Usage

```
get_graph_structure_node_feature(smiles, max_atoms,
    element_list = c(
        "C", "N", "O", "S", "F", "Si", "P", "Cl",
        "Br", "Mg", "Na", "Ca", "Fe",  "Al", "I",
        "B", "K", "Se", "Zn", "H", "Cu", "Mn"))
```

Arguments

`smiles`	SMILES strings
`max_atoms`	maximum number of atoms
`element_list`	list of atom symbols

Value

`A_pad`	a padded or turncated adjacency matrix for each SMILES string
`X_pad`	a padded or turncated node features for each SMILES string
`feature_dim`	dimension of node features
`element_list`	list of atom symbols

Author(s)

Dongmin Jung

References

Balakin, K. V. (2009). Pharmaceutical data mining: approaches and applications for drug discovery. Wiley.

See Also

matlab::padarray, purrr::chuck, rcdk::get.adjacency.matrix, rcdk::get.atoms, rcdk::get.hydrogen.count, rcdk::get.symbol rcdk::parse.smiles

Examples

```
get_graph_structure_node_feature(example_cpi[1, 1], 10)
```

`get_seq_encode_pad` *Vectorization of characters of strings*

Description

A vectorization of characters of strings is necessary. Vectorized characters are padded or truncated.

Usage

```
get_seq_encode_pad(sequences, length_seq, ngram_max = 1, ngram_min = 1,
    lenc = NULL)
```

Arguments

`sequences`	SMILE strings or amino acid sequences
`length_seq`	length of input sequences
`ngram_max`	maximum size of an n-gram (default: 1)
`ngram_min`	minimum size of an n-gram (default: 1)
`lenc`	encoded labels for characters, LableEncoder object fitted by "CatEncoders::LabelEncoder.fit" (default: NULL)

Value

`sequences_encode_pad`	for each SMILES string, an encoded sequence which is padded or truncated
`lenc`	encoded labels for characters
`num_token`	total number of characters

Author(s)

Dongmin Jung

See Also

CatEncoders::LabelEncoder.fit, CatEncoders::transform, keras::pad_sequences, stringdist::qgrams, tokenizers::tokenize_ngrams

Examples

```
if (keras::is_keras_available() & reticulate::py_available()) {
    get_seq_encode_pad(example_cpi[1, 2], 10)
}
```

`metric_concordance_index` *Concordance index*

Description

The concordance index or c-index can be seen as one of the model performance metrics. It represents a good fit of the model.

Author(s)

Dongmin Jung

References

Kose, U., & Alzubi, J. (2020). Deep learning for cancer diagnosis. Springer.

See Also

keras::k_cast, keras::k_equal, keras::k_sum, tensorflow::tf

Examples

```
if (keras::is_keras_available() & reticulate::py_available()) {
    compound_length_seq <- 50
    compound_embedding_dim <- 16
    protein_embedding_dim <- 16
    protein_length_seq <- 100

    mlp_cnn_cpi <- fit_cpi(
        smiles = example_cpi[1:100, 1],
        AAseq = example_cpi[1:100, 2],
        outcome = example_cpi[1:100, 3],
        compound_type = "sequence",
        compound_length_seq = compound_length_seq,
        compound_embedding_dim = compound_embedding_dim,
        protein_length_seq = protein_length_seq,
        protein_embedding_dim = protein_embedding_dim,
        net_args = list(
        compound = "mlp_in_out",
        compound_args = list(
                fc_units = c(10),
                fc_activation = c("relu")),
            protein = "cnn_in_out",
            protein_args = list(
                cnn_filters = c(32),
                cnn_kernel_size = c(3),
                cnn_activation = c("relu"),
                fc_units = c(10),
                fc_activation = c("relu")),
```

```
            fc_units = c(1),
            fc_activation = c("sigmoid"),
            loss = "binary_crossentropy",
            optimizer = keras::optimizer_adam(),
            metrics = custom_metric("concordance_index",
                metric_concordance_index)),
        epochs = 2,
        batch_size = 16)
}
```

`metric_f1_score` *F1-score*

Description

The F1-score is a metric combining precision and recall. It is typically used instead of accuracy in the case of severe class imbalance in the dataset. The higher the values of F1-score, the better the validation of the model.

Author(s)

Dongmin Jung

References

Kubben, P., Dumontier, M., & Dekker, A. (2019). Fundamentals of clinical data science. Springer.

Mishra, A., Suseendran, G., & Phung, T. N. (Eds.). (2020). Soft Computing Applications and Techniques in Healthcare. CRC Press.

See Also

keras::k_equal, keras::k_sum, tensorflow::tf

Examples

```
if (keras::is_keras_available() & reticulate::py_available()) {
    compound_length_seq <- 50
    compound_embedding_dim <- 16
    protein_embedding_dim <- 16
    protein_length_seq <- 100

    mlp_cnn_cpi <- fit_cpi(
        smiles = example_cpi[1:100, 1],
        AAseq = example_cpi[1:100, 2],
        outcome = example_cpi[1:100, 3],
        compound_type = "sequence",
        compound_length_seq = compound_length_seq,
        compound_embedding_dim = compound_embedding_dim,
        protein_length_seq = protein_length_seq,
```

```
        protein_embedding_dim = protein_embedding_dim,
        net_args = list(
        compound = "mlp_in_out",
        compound_args = list(
                fc_units = c(10),
                fc_activation = c("relu")),
            protein = "cnn_in_out",
            protein_args = list(
                cnn_filters = c(32),
                cnn_kernel_size = c(3),
                cnn_activation = c("relu"),
                fc_units = c(10),
                fc_activation = c("relu")),
            fc_units = c(1),
            fc_activation = c("sigmoid"),
            loss = "binary_crossentropy",
            optimizer = keras::optimizer_adam(),
            metrics = custom_metric("F1_score",
                metric_f1_score)),
        epochs = 2,
        batch_size = 16)
}
```

`multiple_sampling_generator` *Generator function for multiple inputs*

Description

This is a generator function that yields batches of data with multiple inputs.

Usage

```
multiple_sampling_generator(X_data, Y_data = NULL, batch_size,
    shuffle = TRUE)
```

Arguments

`X_data`	list of multiple inputs
`Y_data`	targets (default: NULL)
`batch_size`	batch size
`shuffle`	whether to shuffle the data or not (default: TRUE)

Value

generator for "keras::fit" or "keras::predict"

Author(s)

Dongmin Jung

Examples

```
X_data <- c(list(matrix(rnorm(200), ncol = 2)),
    list(matrix(rnorm(200), ncol = 2)))
Y_data <- matrix(rnorm(100), ncol = 1)
multiple_sampling_generator(X_data, Y_data, 32)
```

SARS_CoV2_3CL_Protease

Amino Acid Sequence for the SARS coronavirus 3C-like Protease

---

Description

306 amino acid residues of the SARS coronavirus 3C-like Protease

Usage

```
SARS_CoV2_3CL_Protease
```

Value

amino acid sequence

Author(s)

Dongmin Jung

Source

Huang, K., Fu, T., Glass, L. M., Zitnik, M., Xiao, C., & Sun, J. (2020). DeepPurpose: A Deep Learning Library for Drug-Target Interaction Prediction. Bioinformatics.

seq_check *Check SMILES strings and amino acid sequences*

Description

In real-world cases, most of the data are not complete and contains incorrect values, missing values, and so on. Thus, there may be invalid sequences in the data. This function can find such sequences and remove them from the data. For SMILES strings, the function "webchem::is.smiles" is used. A valid amino acid sequence means a string that only contains capital letters of an alphabet.

Usage

```
seq_check(smiles = NULL, AAseq = NULL, outcome = NULL)
```

Arguments

smiles	SMILES strings (default: NULL)
AAseq	amino acid sequences (default: NULL)
outcome	a variable that indicates how strong two molecules interact with each other or whether there is an interaction between them (default: NULL)

Value

valid sequences

Author(s)

Dongmin Jung

References

Dey, N., Wagh, S., Mahalle, P. N., & Pathan, M. S. (Eds.). (2019). Applied machine learning for smart data analysis. CRC Press.

See Also

webchem::is.smiles

Examples

```
seq_check(smiles = example_cpi[1, 1], outcome = example_cpi[1, 3])
```

seq_preprocessing *Preprocessing for SMILES strings and amino acid sequences*

Description

Preprocessing helps make the data suitable for the model depending on the type of data the preprocessing works upon. Preprocessing is more time consuming for text data. The adjacency matrix and node feature, fingerprint, or string data are preprocessed from sequences.

Usage

```
seq_preprocessing(smiles = NULL,
    AAseq = NULL,
    type,
    convert_canonical_smiles,
    max_atoms,
    length_seq,
    lenc = NULL,
    ngram_max = 1,
    ngram_min = 1)
```

Arguments

smiles	SMILES strings (default: NULL)
AAseq	amino acid sequences (default: NULL)
type	"graph", "fingerprint" or "sequence"
convert_canonical_smiles	SMILES strings are converted to canonical SMILES strings if TRUE
max_atoms	maximum number of atoms for compounds
length_seq	length of compound or protein sequence
lenc	encoded labels for characters of SMILES strings or amino acid sequenes (default: NULL)
ngram_max	maximum size of an n-gram for protein sequences (default: 1)
ngram_min	minimum size of an n-gram for protein sequences (default: 1)

Value

canonical_smiles	canonical representation of SMILES
convert_canonical_smiles	canonical representation is used or not
A_pad	padded or turncated adjacency matrix of compounds if type is "graph"
X_pad	padded or turncated node features of compounds if type is "graph"

fp	fingerprint of compounds if type is "fingerprint"
sequences_encode_pad	encoded sequences which are padded or truncated
lenc	encoded labels for characters of SMILES strings or amino acid sequenes
length_seq	length of compound or protein sequence
num_tokens	total number of characters of compounds or proteins

Author(s)

Dongmin Jung

References

Dey, N., Wagh, S., Mahalle, P. N., & Pathan, M. S. (Eds.). (2019). Applied machine learning for smart data analysis. CRC Press.

Examples

```
seq_preprocessing(smiles = cbind(example_cpi[1, 1]),
    type = "fingerprint",
    convert_canonical_smiles = TRUE)
```

Index

antiviral_drug, 2

cnn_in_out *(*encoder_in_out*)*, 8
cpi_model, 3

encoder_in_out, 8
example_bioassay, 10
example_cci, 11
example_chem, 11
example_cpi, 12
example_pd, 12
example_ppi, 13
example_prot, 13

fit_cpi *(*cpi_model*)*, 3

gcn_in_out *(*encoder_in_out*)*, 8
get_canonical_smiles, 14
get_fingerprint, 15
get_graph_structure_node_feature, 16
get_seq_encode_pad, 17

metric_concordance_index, 18
metric_f1_score, 19
mlp_in_out *(*encoder_in_out*)*, 8
multiple_sampling_generator, 20

predict_cpi *(*cpi_model*)*, 3

rnn_in_out *(*encoder_in_out*)*, 8

SARS_CoV2_3CL_Protease, 21
seq_check, 22
seq_preprocessing, 23