

Cheat Sheet: Generative AI Advanced Fine-Tuning for LLMs

Package/Method	Description	Code Example
CUDA-compatible GPU	Available in the system using PyTorch, a popular deep-learning framework. If a GPU is available, it assigns the device variable to "cuda" (CUDA, the parallel computing platform and application programming interface model developed by NVIDIA). If a GPU is not available, it assigns the device variable to "cpu" (which means the code will run on the CPU instead).	<pre>device = torch.device("cuda" if torch.cuda.is_available() else "cpu") device</pre>
collate_fn	Shows that collate_fn function is used in conjunction with data loaders to customize the way batches are created from individual samples. A collate_batch function in PyTorch is used with data loaders to customize batch creation from individual samples. It processes a batch of data, including labels and text sequences. It applies the text_pipeline function to preprocess the text. The processed data is then converted into PyTorch tensors and returned as a tuple containing the label tensor, text tensor, and offsets tensor representing the starting positions of each text sequence in the combined tensor. The function also ensures that the returned tensors are moved to the specified device (GPU) for efficient computation.	<pre>from torch.nn.utils.rnn import pad_sequence def collate_batch(batch): label_list, text_list = [], [] for _label, _text in batch: label_list.append(_label) text_list.append(torch.tensor(text_pipeline(_text), dtype=torch.i label_list = torch.tensor(label_list, dtype=torch.int64) text_list = pad_sequence(text_list, batch_first=True) return label_list.to(device), text_list.to(device)</pre>
Training function	Helps in the training model, iteratively update the model's parameters to minimize the loss function. It improves the model's performance on a given task.	<pre>def train_model(model, optimizer, criterion, train_data_loader, valid_data_loader): cum_loss_list = [] acc_epoch = [] acc_old = 0 model_path = os.path.join(save_dir, file_name) acc_dir = os.path.join(save_dir, os.path.splitext(file_name)[0] + "_a loss_dir = os.path.join(save_dir, os.path.splitext(file_name)[0] + "_ time_start = time.time() for epoch in tqdm(range(1, epochs + 1)): model.train() #print(model) #for parm in model.parameters(): # print(parm.requires_grad) cum_loss = 0 for idx, (label, text) in enumerate(train_data_loader): optimizer.zero_grad() label, text = label.to(device), text.to(device) predicted_label = model(text) loss = criterion(predicted_label, label) loss.backward() #print(loss) torch.nn.utils.clip_grad_norm_(model.parameters(), 1.0) optimizer.step() cum_loss += loss.item() print(f"Epoch {epoch}/{epochs} - Loss: {cum_loss}") cum_loss_list.append(cum_loss) accu_val = evaluate_no_tqdm(valid_data_loader, model) acc_epoch.append(accu_val) if model_path and accu_val > acc_old: print(accu_val) acc_old = accu_val if save_dir is not None: pass #print("save model epoch", epoch) #torch.save(model.state_dict(), model_path) #save_list_to_file(lst=acc_epoch, filename=acc_dir) #save_list_to_file(lst=cum_loss_list, filename=loss_dir) time_end = time.time() print(f"Training time: {time_end - time_start}")</pre>
DPO configuration	Involves training arguments, processing logging steps, evaluation strategies, and scheduling for model updates.	<pre># DPO configuration training_args = DPOConfig(# The beta parameter for the DPO loss function #beta is the temperature parameter for the DPO loss, typically someth beta=0.1,</pre>

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	Configuring DPO involves setting up administrative and technical measures for complying with data protection laws and regulations.	<pre> # The output directory for the training output_dir="dpo", # The number of training epochs num_train_epochs=5, # The batch size per device during training per_device_train_batch_size=1, # The batch size per device during evaluation per_device_eval_batch_size=1, # Whether to remove unused columns from the dataset remove_unused_columns=False, # The number of steps between logging training progress logging_steps=10, # The number of gradient accumulation steps gradient_accumulation_steps=1, # The learning rate for the optimization learning_rate=1e-4, # The evaluation strategy (e.g., after each step or epoch) eval_strategy="epoch", # The number of warmup steps for the learning rate scheduler warmup_steps=2, # Whether to use 16-bit (float16) precision fp16=False, # The number of steps between saving checkpoints save_steps=500, # The maximum number of checkpoints to keep #save_total_limit=2, # The reporting backend to use (set to 'none' to disable, you can als report_to='none' </pre>
DPOTraining class	Designed to equip professionals with the knowledge and skills for managing and overseeing data protection strategies in compliance with relevant laws and regulations.	<pre> tokenizer.pad_token = tokenizer.eos_token # Create a DPO trainer # This trainer will handle the fine-tuning of the model using the DPO tec trainer = DPOTrainer(# The model to be fine-tuned model, # The reference model (not used in this case because LoRA has bee ref_model=None, # The DPO training configuration args=training_args, # The beta parameter for the DPO loss function beta=0.1, # The training dataset train_dataset=train_dataset, # The evaluation dataset eval_dataset=eval_dataset, # The tokenizer for the model tokenizer=tokenizer, # The PEFT (Parallel Efficient Finetuning) configuration peft_config=peft_config, # The maximum prompt length max_prompt_length=512, # The maximum sequence length max_length=512,) </pre>
Retrieve and plot the training loss versus evaluation loss	Helps to retrieve log history and save it for data frame log. It also plots train and evaluation losses for epoch.	<pre> # Retrieve log_history and save it to a dataframe log = pd.DataFrame(trainer.state.log_history) log_t = log[log['loss'].notna()] log_e = log[log['eval_loss'].notna()] # Plot train and evaluation losses plt.plot(log_t["epoch"], log_t["loss"], label = "train_loss") plt.plot(log_e["epoch"], log_e["eval_loss"], label = "eval_loss") plt.legend() plt.show() </pre>
Traverse the IMDB data set	This code snippet traverses the IMDB data set by obtaining, loading, and exploring the data set.	<pre> class IMDBDataset(Dataset): def __init__(self, root_dir, train=True): """ root_dir: The base directory of the IMDB dataset. </pre>

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	It also performs basic operations, visualizes the data, and analyzes and interprets the data set.	<pre> train: A boolean flag indicating whether to use training or test """ self.root_dir = os.path.join(root_dir, "train" if train else "test") self.neg_files = [os.path.join(self.root_dir, "neg", f) for f in self.pos_files = [os.path.join(self.root_dir, "pos", f) for f in self.files = self.neg_files + self.pos_files self.labels = [0] * len(self.neg_files) + [1] * len(self.pos_files) self.pos_inx=len(self.pos_files) def __len__(self): return len(self.files) def __getitem__(self, idx): file_path = self.files[idx] label = self.labels[idx] with open(file_path, 'r', encoding='utf-8') as file: content = file.read() return label, content </pre>
Iterators to train and test data sets	This code snippet indicates a path to the IMDB data set directory by combining temporary and subdirectory names. This code sets up the training and testing data iterators, retrieves the starting index of the training data, and prints the items from the training data set at indices.	<pre> root_dir = tempdir.name + '/' + 'imdb_dataset' train_iter = IMDBDataset(root_dir=root_dir, train=True) # For training data test_iter = IMDBDataset(root_dir=root_dir, train=False) # For test data start=train_iter.pos_inx for i in range(-10,10): print(train_iter[start+i]) </pre>
yield_tokens function	Generates tokens from the collection of text data samples. The code snippet processes each text in 'data_iter' through the tokenizer and yields tokens to generate efficient, on-the-fly token generation suitable for tasks such as training machine learning models.	<pre> tokenizer = get_tokenizer("basic_english") def yield_tokens(data_iter): """Yield tokens for each data sample.""" for _, text in data_iter: yield tokenizer(text) </pre>
Load pretrained model and its evaluation on test data	This code snippet helps download a pretrained model from URL, loads it into a specific architecture, and evaluates it on a test data set for assessing its performance.	<pre> urlopened = urlopen('https://cf-courses-data.s3.us.cloud-object-storage.a model_ = Net(vocab_size=vocab_size, num_class=2).to(device) model_.load_state_dict(torch.load(io.BytesIO(urlopened.read())), map_locat evaluate(test_data_loader, model_) </pre>
Loading the Hugging Face model	This code snippet initiates a tokenizer using a pretrained 'bert-base-cased' model. It also downloads a pretrained model for the masked language model (MLM) task, and how to load the model configurations from a pretrained model.	<pre> # Instantiate a tokenizer using the BERT base cased model tokenizer = AutoTokenizer.from_pretrained("bert-base-cased") # Download pretrained model from huggingface.co and cache. model = BertForMaskedLM.from_pretrained('bert-base-cased') # You can also start training from scratch by loading the model configuration # config = AutoConfig.from_pretrained("google-bert/bert-base-cased") # model = BertForMaskedLM.from_config(config) </pre>

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Training a BERT model for MLM task	This code snippet trains the model with the specified parameters and data set. However, ensure that the 'SFTTrainer' is the appropriate trainer class for the task and the model is properly defined for training.	<pre> training_args = TrainingArguments(output_dir="./trained_model", # Specify the output directory for the overwrite_output_dir=True, do_eval=False, learning_rate=5e-5, num_train_epochs=1, # Specify the number of training epochs per_device_train_batch_size=2, # Set the batch size for training save_total_limit=2, # Limit the total number of saved checkpoints logging_steps = 20) dataset = load_dataset("imdb", split="train") trainer = SFTTrainer(model, args=training_args, train_dataset=dataset, dataset_text_field="text",) </pre>
Load the model and tokenizer	Useful for tasks where you need to quickly classify the sentiment of a piece of text with a pretrained, efficient transformer model.	<pre> tokenizer = DistilBertTokenizer.from_pretrained("distilbert-base-uncased- model = DistilBertForSequenceClassification.from_pretrained("distilbert-b </pre>
torch.no_grad()	The torch.no_grad() context manager disables gradient calculation. This reduces memory consumption and speeds up computation, as gradients are unnecessary for inference (i.e., when you are not training the model). The **inputs syntax is used to unpack a dictionary of keyword arguments in Python.	<pre> # Perform inference with torch.no_grad(): outputs = model(**inputs) </pre>
Logits	The raw, unnormalized predictions of the model. Let's extract the logits from the model's outputs to perform further processing, such as determining the predicted class or calculating probabilities.	<pre> logits = outputs.logits logits.shape </pre>
GPT-2 tokenizer	Helps to initialize the GPT-2 tokenizer using a pretrained model to handle encoding and decoding.	<pre> # Load the tokenizer and model tokenizer = GPT2Tokenizer.from_pretrained("gpt2") </pre>
Load GPT-2 model	This code snippet initializes and loads the pretrained GPT-2 model. This code makes the GPT-2 model ready for generating text or other language tasks.	<pre> # Load the tokenizer and model model = GPT2LMHeadModel.from_pretrained("gpt2") </pre>

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Generate text	This code snippet generates text sequences based on the input and doesn't compute the gradient to generate output.	<pre># Generate text output_ids = model.generate(inputs.input_ids, attention_mask=inputs.attention_mask, pad_token_id=tokenizer.eos_token_id, max_length=50, num_return_sequences=1) output_ids or with torch.no_grad(): outputs = model(**inputs) outputs</pre>
Decode the generated text	This code snippet decodes the text from the token IDs generated by a model. The code also decodes it into a readable string to print it.	<pre># Decode the generated text generated_text = tokenizer.decode(output_ids[0], skip_special_tokens=True) print(generated_text)</pre>
Hugging Face pipeline() function	The pipeline() function from the Hugging Face Transformers library is a high-level API designed to simplify the usage of pretrained models for various natural language processing (NLP) tasks. It abstracts the complexities of model loading, tokenization, inference, and post-processing, allowing users to perform complex NLP tasks with just a few lines of code.	<pre>transformers.pipeline(task: str, model: Optional = None, config: Optional = None, tokenizer: Optional = None, feature_extractor: Optional = None, framework: Optional = None, revision: str = 'main', use_fast: bool = True, model_kwargs: Dict[str, Any] = None, **kwargs)</pre>
expected_outputs	Tokenize instructions and the instructions_with_responses. Then, count the number of tokens in instructions, and discard the equivalent amount of tokens from the beginning of the tokenized instructions_with_responses vector. Finally, discard the final token in instructions_with_responses, corresponding to the eos token. Decode the resulting vector using the tokenizer, resulting in the expected_output.	<pre>expected_outputs = [] instructions_with_responses = formatting_prompts_func(test_dataset) instructions = formatting_prompts_func_no_response(test_dataset) for i in tqdm(range(len(instructions_with_responses))): tokenized_instruction_with_response = tokenizer(instructions_with_res tokenized_instruction = tokenizer(instructions[i], return_tensors="pt expected_output = tokenizer.decode(tokenized_instruction_with_respons expected_outputs.append(expected_output)</pre>
ListDataset	Inherits from Dataset and creates a torch Dataset from a list. This class is then used to generate a Dataset object from instructions.	<pre>class ListDataset(Dataset): def __init__(self, original_list): self.original_list = original_list def __len__(self): return len(self.original_list) def __getitem__(self, i): return self.original_list[i] instructions_torch = ListDataset(instructions)</pre>

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gen_pipeline	This code snippet takes the token IDs from the model output, decodes it from the table text, and prints the responses.	<pre> gen_pipeline = pipeline("text-generation", model=model, tokenizer=tokenizer, device=device, batch_size=2, max_length=50, truncation=True, padding=False, return_full_text=False) </pre>
torch.no_grad()	This code generates text from the given input using a pipeline while optimizing resource usage by limiting input size and reducing gradient calculations.	<pre> with torch.no_grad(): # Due to resource limitation, only apply the function on 3 records us pipeline_iterator= gen_pipeline(instructions_torch[:3], max_length=50, # this is set to 50 du num_beams=5, early_stopping=True,) generated_outputs_base = [] for text in pipeline_iterator: generated_outputs_base.append(text[0]["generated_text"]) </pre>
load_dataset	The data set is loaded using the load_dataset function from the data sets library, specifically loading the "train" split.	<pre> dataset_name = "imdb" ds = load_dataset(dataset_name, split = "train") N = 5 for sample in range(N): print('text',ds[sample]['text']) print('label',ds[sample]['label']) ds = ds.rename_columns({"text": "review"}) ds ds = ds.filter(lambda x: len(x["review"]) > 200, batched=False) </pre>
build_dataset	Incorporates the necessary steps to build a data set object for use as an input to PPOTrainer.	<pre> del(ds) dataset_name="imdb" ds = load_dataset(dataset_name, split="train") ds = ds.rename_columns({"text": "review"}) def build_dataset(config, dataset_name="imdb", input_min_text_length=2, i """ Build dataset for training. This builds the dataset from `load_dataset` customize this function to train the model on its own dataset. Args: dataset_name (`str`): The name of the dataset to be loaded. Returns: dataloader (`torch.utils.data.DataLoader`): The dataloader for the dataset. """ tokenizer = AutoTokenizer.from_pretrained(config.model_name) tokenizer.pad_token = tokenizer.eos_token # load imdb with datasets ds = load_dataset(dataset_name, split="train") ds = ds.rename_columns({"text": "review"}) ds = ds.filter(lambda x: len(x["review"]) > 200, batched=False) input_size = LengthSampler(input_min_text_length, input_max_text_leng def tokenize(sample): sample["input_ids"] = tokenizer.encode(sample["review"])[1: input_ sample["query"] = tokenizer.decode(sample["input_ids"]) return sample ds = ds.map(tokenize, batched=False) ds.set_format(type="torch") return ds </pre>

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Initialize PPOTrainer	<p>Proximal policy optimization (PPO) is a reinforcement learning algorithm that is particularly well-suited for training generative models, including those used for chatbots. It helps address specific challenges in training these models, such as maintaining coherent and contextually appropriate dialogues. It improves policy gradient methods for chatbots by using a clipped objective function, which ensures gradual and stable policy updates. Specified configuration and components. config: Configuration settings for PPO training, such as learning rate and model name. model: The primary model to be fine-tuned using PPO. tokenizer: Tokenizer corresponding to the model, used for processing input text. dataset: Data set to be used for training, providing the input data for the model. data_collator: Data collator to handle batching and formatting of the input data.</p>	<pre>ppo_trainer = PPOTrainer(config, model, ref_model, tokenizer, dataset=dat print("ppo_trainer object ",ppo_trainer) device = ppo_trainer.accelerator.device if ppo_trainer.accelerator.num_processes == 1: device = 0 if torch.cuda.is_available() else "cpu" print(device)</pre>
output_length_sampler	<p>Initialized with LengthSampler(output_min_length, output_max_length). This object is used to sample output lengths for the generated sequences, ensuring they fall within the specified minimum and maximum length range. By varying the lengths, we can produce more diverse and natural outputs from the language model, preventing the generation of overly short or excessively long sequences and enhancing the overall quality of the responses.</p>	<pre>output_min_length = 4 output_max_length = 16 output_length_sampler = LengthSampler(output_min_length, output_max_lengt</pre>
max_new_tokens	<p>Set the max_new_tokens parameter in the generation_kwargs dictionary to the value of gen_len, which was sampled from output_length_sampler. This ensures that the maximum number of new tokens generated by the language model is within the desired length range, promoting more controlled and appropriately lengthened responses.</p>	<pre>generation_kwargs["max_new_tokens"] = gen_len generation_kwargs</pre>
Text generation function	<p>Tokenizes input text, generates a response, and decodes it.</p>	<pre>gen_kwargs = {"min_length": -1, "top_k": 0.0, "top_p": 1.0, "do_sample": def generate_some_text(input_text,my_model): # Tokenize the input text input_ids = tokenizer(input_text, return_tensors='pt').input_ids.to(d generated_ids = my_model.generate(input_ids,**gen_kwargs) # Decode the generated text generated_text_ = tokenizer.decode(generated_ids[0], skip_special_tok return generated_text_</pre>
Generate text with PPO model	<p>Generate text using the PPO-trained model.</p>	<pre>input_text = "Once upon a time in a land far" generated_text=generate_some_text(input_text,model_1) generated_text</pre>

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Sentiment analysis	Analyze the sentiment of the generated text using sentiment_pipe.	<pre> pipe_outputs = sentiment_pipe(generated_text, **sent_kwargs) pipe_outputs </pre>
Generate text with reference model	Generate text using the reference model.	<pre> generated_text = generate_some_text(input_text, ref_model) generated_text </pre>
compare_models_on_dataset	This code snippet initializes the generation parameters, prepares the data set, and converts queries into tensors for the model input. It also generates a model, helps decode the text, and uses sentiment analysis to compute sentiment scores for concentrated texts before and after applying the model. This code also compiles results, stores original queries, and converts the dictionary to a pandas data frame for easy analysis.	<pre> def compare_models_on_dataset(model, ref_model, dataset, tokenizer, senti gen_kwargs = { "min_length": -1, "top_k": 0.0, "top_p": 1.0, "do_sample": True, "pad_token_id": tokenizer.eos_token_id } bs = 16 game_data = dict() dataset.set_format("pandas") df_batch = dataset[:].sample(bs) game_data["query"] = df_batch["query"].tolist() query_tensors = df_batch["input_ids"].tolist() response_tensors_ref, response_tensors = [], [] for i in range(bs): gen_len = output_length_sampler() output = ref_model.generate(torch.tensor(query_tensors[i]).unsqueeze(dim=0).to(device), max_new_tokens=gen_len, **gen_kwargs).squeeze()[-gen_len:] response_tensors_ref.append(output) output = model.generate(torch.tensor(query_tensors[i]).unsqueez max_new_tokens=gen_len, **gen_kwargs).squeeze()[-gen_len:] response_tensors.append(output) game_data["response (before)"] = [tokenizer.decode(response_tensors_r game_data["response (after)"] = [tokenizer.decode(response_tensors[i] texts_before = [q + r for q, r in zip(game_data["query"], game_data[" game_data["rewards (before)"] = [output[1]["score"] for output in sen texts_after = [q + r for q, r in zip(game_data["query"], game_data["r game_data["rewards (after)"] = [output[1]["score"] for output in sent df_results = pd.DataFrame(game_data) return df_results </pre>

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Tokenizing data	This code snippet defines a function 'compare_models_on_dataset' for comparing the performance of two models by initializing generation parameters and setting the batch size, preparing the data set in the pandas format, and sampling the batch queries.	<pre># Instantiate a tokenizer using the BERT base cased model tokenizer = AutoTokenizer.from_pretrained("bert-base-cased") # Define a function to tokenize examples def tokenize_function(examples): # Tokenize the text using the tokenizer # Apply padding to ensure all sequences have the same length # Apply truncation to limit the maximum sequence length return tokenizer(examples["text"], padding="max_length", truncation=True) # Apply the tokenize function to the dataset in batches tokenized_datasets = dataset.map(tokenize_function, batched=True)</pre>
Training loop	The train_model function trains a model using a set of training data provided through a dataloader. It begins by setting up a progress bar to help monitor the training progress visually. The model is switched to training mode, which is necessary for certain model behaviors like dropout to work correctly during training. The function processes the data in batches for each epoch, which involves several steps for each batch: transferring the data to the correct device (like a GPU), running the data through the model to get outputs and calculate loss, updating the model's parameters using the calculated gradients, adjusting the learning rate, and clearing the old gradients.	<pre>def train_model(model,tr_dataloader): # Create a progress bar to track the training progress progress_bar = tqdm(range(num_training_steps)) # Set the model in training mode model.train() tr_losses=[] # Training loop for epoch in range(num_epochs): total_loss = 0 # Iterate over the training data batches for batch in tr_dataloader: # Move the batch to the appropriate device batch = {k: v.to(device) for k, v in batch.items()} # Forward pass through the model outputs = model(**batch) # Compute the loss loss = outputs.loss # Backward pass (compute gradients) loss.backward() total_loss += loss.item() # Update the model parameters optimizer.step() # Update the learning rate scheduler lr_scheduler.step() # Clear the gradients optimizer.zero_grad() # Update the progress bar progress_bar.update(1) tr_losses.append(total_loss/len(tr_dataloader)) #plot loss plt.plot(tr_losses) plt.title("Training loss") plt.xlabel("Epoch") plt.ylabel("Loss") plt.show()</pre>

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evaluate_model function	Works similarly to the train_model function but is used for evaluating the model's performance instead of training it. It uses a dataloader to process data in batches, setting the model to evaluation mode to ensure accuracy in measurements and disabling gradient calculations since it's not training. The function calculates predictions for each batch, updates an accuracy metric, and finally, prints the overall accuracy after processing all batches.	<pre> def evaluate_model(model, evl_dataloader): # Create an instance of the Accuracy metric for multiclass classifica metric = Accuracy(task="multiclass", num_classes=5).to(device) # Set the model in evaluation mode model.eval() # Disable gradient calculation during evaluation with torch.no_grad(): # Iterate over the evaluation data batches for batch in evl_dataloader: # Move the batch to the appropriate device batch = {k: v.to(device) for k, v in batch.items()} # Forward pass through the model outputs = model(**batch) # Get the predicted class labels logits = outputs.logits predictions = torch.argmax(logits, dim=-1) # Accumulate the predictions and labels for the metric metric(predictions, batch["labels"]) # Compute the accuracy accuracy = metric.compute() # Print the accuracy print("Accuracy:", accuracy.item()) </pre>
llm_model	This code snippet defines function 'llm_model' for generating text using the language model from the mistral.ai platform, specifically the 'mistral-8x7b-instruct-v01' model. The function helps in customizing generating parameters and interacts with IBM Watson's machine learning services.	<pre> def llm_model(prompt_txt, params=None): model_id = 'mistralai/mistral-8x7b-instruct-v01' default_params = { "max_new_tokens": 256, "min_new_tokens": 0, "temperature": 0.5, "top_p": 0.2, "top_k": 1 } if params: default_params.update(params) parameters = { GenParams.MAX_NEW_TOKENS: default_params["max_new_tokens"], # th GenParams.MIN_NEW_TOKENS: default_params["min_new_tokens"], # thi GenParams.TEMPERATURE: default_params["temperature"], # this rand GenParams.TOP_P: default_params["top_p"], GenParams.TOP_K: default_params["top_k"] } credentials = { "url": "https://us-south.ml.cloud.ibm.com" } project_id = "skills-network" model = Model(model_id=model_id, params=parameters, credentials=credentials, project_id=project_id) mistral_llm = WatsonxLLM(model=model) response = mistral_llm.invoke(prompt_txt) return response </pre>
RewardTrainer	The RewardTrainer orchestrates the training process, handling tasks such as batching, optimization, evaluation, and saving model checkpoints. It is particularly useful for training models that need to learn from feedback signals, improving their ability to generate high-quality responses.	<pre> # Initialize RewardTrainer trainer = RewardTrainer(model=model, args=training_args, tokenizer=tokenizer, train_dataset=dataset_dict['train'], eval_dataset=dataset_dict['test'], peft_config=peft_config,) </pre>