

---

# MMModal - Multi-Images Multi-Audio Multi-turn Multi-Modal

---

Husein Zolkepli\*

Aisyah Razak<sup>†</sup>

Kamarul Adha<sup>‡</sup>

Ariff Nazhan<sup>§</sup>

## Abstract

Our contribution introduces a groundbreaking multimodal large language model designed to comprehend multi-images, multi-audio, and multi-images-multi-audio within a single multiturn session. Leveraging state-of-the-art models, we utilize the SigLIP encoder for visual inputs and the Whisper Encoder for audio inputs. Notably, this multimodal large language model is bilingual, proficient in understanding both English and Malay simultaneously. We proudly unveil three versions of this model: Qwen1.5 with 0.5B parameters, TinyLlama with 1.1B parameters, and Mistral with 7B parameters. With its ability to navigate diverse modalities and languages, our model represents a significant advancement for the Malaysian context and beyond. All models released at [HuggingFace Mesolitica Multimodal Malaysian LLM](#).

## 1 Introduction

Language models trained with instructions have demonstrated remarkable performance across various domains. However, their limitation in handling only text-based data hampers their applicability. Recent advancements in multimodal pre-training have shown the potential to integrate knowledge from diverse modalities into a unified representation [1–3].

The introduction of OpenAI’s GPT-4 [3], which incorporates LLM with visual understanding capability, marked a milestone in the industry’s progress, demonstrating significant advancements in addressing open-ended visual question-answering (VQA) tasks. Pioneering research initiatives such as LLaVA [2] and MiniGPT-4 [4] provide insightful directions in visual and text understanding capability. Their findings suggest that by incorporating visual encoders into existing LLMs and fine-tuning them using multi-modal instruction-tuning datasets, LLMs can be effectively transformed into multimodal LLMs. While Macaw-LLM [1] introduces the integration of LLM with four different modalities: text, audio, video, and images. They successfully process information from different inputs effectively, enabling seamless information retrieval across domains. Existing dataset for multi-modal instruction made available from [2] primarily supports instruction-following data involving visual content for conversation, detailed description and complex reasoning data.

Despite recent advancements, there remains a lack of current research on multimodal models capable of handling multiple images or audio inputs along with multi-turn dialogue. Moreover, there is a lack of existing multimodal datasets incorporating multi-turn interactions with multiple audio and image inputs, and little consideration has been given to the Malaysian context. To address these gaps, our proposal introduces MModal, a multimodal large language model fine-tuned for multi-modal instruction, integrating image, audio, and text modalities within a single model architecture. Additionally, we present a corpus and employ an adaptive synthetic data generation method tailored to provide access to multi-image, multi-audio, multi-turn datasets with regards to languages in Malay and English.

---

\*husein@mesolitica.com

<sup>†</sup>aisyahrazak171@gmail.com

<sup>‡</sup>kamarul.adha360@gmail.com

<sup>§</sup>ariffnazhn@gmail.com

- **Synthetic Audio Instruction Dataset:** To construct Synthetic Audio Instruction Dataset, our approach involves gathering extracted audio content from YouTube videos. We employed the Whisper Large V3 model for pseudolabeling to transcribe the audio contents from scraped Youtube videos, followed by a post-filtering process based on score thresholds to ensure high-quality datasets. We then utilized the Mixtral-8x7B-Instruct-v0.1 Model to generate multiturn dialogue instruction-following data involving the audio context.
- **Synthetic Visual Malaysian Context Dataset:** We collected images from Malaysian websites along with their descriptions. Through data processing, we converted this information into conversational examples to better incorporate Malaysian context into our model.
- **Synthetic Multi-Images Multi-Audio relationship Dataset:** Our method involved randomly combining images, audios or pairing them together to create a dataset illustrating relationships of different images and audios. We utilized Mistral to generate multiturn dialogues, prompting the model to respond based on the images, audio captions, and descriptions. This enabled us to collect a corpus tailored for focusing on relationships within multi-modal content, encompassing both images and audio.
- **Pretraining Feature Alignment:** Our approach adopts a two-step training procedure to integrate multimodal and multiturn capabilities into our model. The initial step entails pretraining the feature alignment module. Through this process, we align the image and audio features with the pre-trained word embeddings of the Large Language Model (LLM). Specifically, this step involves training the projection layer to ensure alignment between the multi-modal features and textual representations. This alignment facilitates seamless integration of diverse modalities within the model architecture.
- **Finetuned Multi-Images Multi-Audio Multi-turn Model:** After pre-training for feature alignment, the projector module becomes familiar with the visual and embedding space. However, it still lacks the capability to discern the finer details of images and audios, or to respond to human questions and instructions effectively. In the second stage, we utilize generated synthetic Multimodal data to enhance performance and further align the embeddings with the Large Language Model (LLM). This step improves the LLM's ability to produce more natural and reliable language outputs for multimodal instructions.

## 2 Synthetic Data Generation for Audio Instructions

We gathered the audio from youtube and use pseudolabeling approach to transcribe the audio from speech to text using OpenAI's Whisper Large V3.

We then generate synthetic audio instruction using [mistralai/Mixtral-8x7B-Instruct-v0.1](#) model. This model, specifically designed for instruction generation, integrates advanced natural language understanding capabilities to produce coherent and contextually relevant audio instructions from the transcribed text.

Below is the prompt to generate the synthetic dataset:

```
anda tahu keuntungan boleh lebih tinggi daripada keuntungan kewangan rumah maka
saya tidak akan mencari dalam akaun saya akan mencari ke dalam ethereum atau
beberapa crypto punks bergantung pada faktor risiko anda kerana rumah kajang
dihantar tidak mengganggu dsr saya sejauh ini jadi sekarang apa posisi saya
untuk mendapatkan kewangan ketiga jadi mungkin setelah melihat sekeliling saya
menemui seorang penjual yang dapat menutupi perhubungan tetapi bank hanya
menerima 70% dari itu saya boleh membayar perbezaan dengan menggunakan wang
ini kerana sekali lagi ia menyusahkan saya dan aset tetapi jika anda tidak
selesa dengan mencari
```

```
generate questions based on context above.
```

An example of generated dataset:

```
{'context': 'anda tahu keuntungan boleh lebih tinggi daripada keuntungan kewangan
rumah maka saya tidak akan mencari dalam akaun saya akan mencari ke dalam
ethereum atau beberapa crypto punks bergantung pada faktor risiko anda kerana
rumah kajang dihantar tidak mengganggu dsr saya sejauh ini jadi sekarang apa
```

posisi saya untuk mendapatkan kewangan ketiga jadi mungkin setelah melihat sekeliling saya menemui seorang penjual yang dapat menutupi perhubungan tetapi bank hanya menerima 70% dari itu saya boleh membayar perbezaan dengan menggunakan wang ini kerana sekali lagi ia menyusahkan saya dan aset tetapi jika anda tidak selesa dengan mencari',

```
'chat': [{'role': 'user',
'content': 'Why might someone consider investing in cryptocurrencies like
Ethereum instead of traditional financial investments such as real estate?',
'content_ms': 'Mengapakah seseorang mungkin mempertimbangkan untuk melabur dalam
mata wang kripto seperti Ethereum dan bukannya pelaburan kewangan tradisional
seperti hartanah?'}],
{'role': 'assistant',
'content': 'There are several reasons why someone might consider investing in
cryptocurrencies like Ethereum instead of traditional financial investments
such as real estate:\n\n1. Potential for higher returns: Cryptocurrencies
have the potential for much higher returns compared to traditional financial
investments. While the real estate market can be profitable, the potential
for exponential growth in the cryptocurrency market is significantly
higher.\n2. Diversification: Investing in cryptocurrencies can provide a
diversification benefit to an investment portfolio. By investing in a variety
of assets, including cryptocurrencies, investors can spread their risk and
potentially increase their overall returns.\n3. Liquidity: Cryptocurrencies
are generally more liquid than real estate investments. It is easier to buy
and sell cryptocurrencies, and they can be quickly converted into cash.\n4.
Accessibility: Investing in cryptocurrencies is generally more accessible
than investing in real estate. There are fewer barriers to entry, and it is
easier to get started with a smaller amount of money.\n5. Decentralization:
Cryptocurrencies are decentralized, meaning they are not controlled by any
government or financial institution. This can provide a level of independence
and autonomy that is not possible with traditional financial
investments.\n\nHowever, it is important to note that investing in
cryptocurrencies is also riskier than traditional financial investments. The
value of cryptocurrencies can be highly volatile, and there is a risk of
losing all or a significant portion of the investment. Therefore, it is
important to carefully consider your own risk tolerance and financial
situation before investing in cryptocurrencies.',
'content_ms': 'Terdapat beberapa sebab mengapa seseorang mungkin mempertimbangkan
untuk melabur dalam mata wang kripto seperti Ethereum dan bukannya pelaburan
kewangan tradisional seperti hartanah:\n\n1. Potensi untuk pulangan yang
lebih tinggi: Mata wang kripto mempunyai potensi untuk pulangan yang lebih
tinggi berbanding dengan pelaburan kewangan tradisional. Walaupun pasaran
hartanah boleh menguntungkan, potensi pertumbuhan eksponen dalam pasaran mata
wang kripto adalah jauh lebih tinggi.\n2. Kepelbagaian: Melabur dalam mata
wang kripto boleh memberikan manfaat kepelbagaian kepada portfolio pelaburan.
Dengan melabur dalam pelbagai aset, termasuk mata wang kripto, pelabur boleh
menyebarkan risiko mereka dan berpotensi meningkatkan pulangan keseluruhan
mereka.\n3. Kecairan: Mata wang kripto biasanya lebih cair daripada pelaburan
hartanah. Lebih mudah untuk membeli dan menjual mata wang kripto, dan ia
boleh ditukar dengan cepat kepada wang tunai.\n4. Kebolehcapaian: Melabur
dalam mata wang kripto secara umumnya lebih mudah diakses daripada melabur
dalam hartanah. Terdapat lebih sedikit halangan untuk masuk, dan lebih mudah
untuk bermula dengan jumlah wang yang lebih kecil.\n5. Desentralisasi: Mata
wang kripto adalah terdesentralisasi, bermakna ia tidak dikawal oleh
mana-mana kerajaan atau institusi kewangan. Ini boleh memberikan tahap
kebebasan dan autonomi yang tidak mungkin dilakukan dengan pelaburan kewangan
tradisional.\n\nWalau bagaimanapun, adalah penting untuk ambil perhatian
bahawa melabur dalam mata wang kripto juga lebih berisiko daripada pelaburan
kewangan tradisional. Nilai mata wang kripto boleh menjadi sangat tidak
menentu, dan terdapat risiko kehilangan semua atau sebahagian besar
pelaburan. Oleh itu, adalah penting untuk mempertimbangkan dengan teliti
toleransi risiko dan keadaan kewangan anda sendiri sebelum melabur dalam mata
wang kripto.'}],
{'role': 'user',
'content': 'mengapa orang menggunakan blockchain untuk mengurus siasia digital',
```

```

'content_ms': 'mengapa orang menggunakan blockchain untuk menguruskan sisa
digital'}},
{'role': 'assistant',
'content': 'There are several reasons why people use blockchain technology to
manage digital assets:\n\n1. Security: Blockchain technology provides a high
level of security for managing digital assets. The decentralized nature of
blockchain makes it difficult for hackers to manipulate or steal digital
assets.\n2. Transparency: Blockchain provides a transparent record of all
transactions related to a digital asset. This makes it easier to track
ownership and verify the authenticity of the asset.\n3. Accessibility:
Blockchain technology allows for the easy transfer and management of digital
assets, making them accessible to anyone with an internet connection.\n4.
Immutability: Once data is recorded on a blockchain, it cannot be altered or
deleted. This ensures that the record of ownership and transactions related
to a digital asset is permanent and cannot be tampered with.\n5.
Programmability: Blockchain technology allows for the creation of smart
contracts, which are self-executing contracts with the terms of the agreement
directly written into code. This enables automatic and secure transfer of
digital assets based on predefined conditions.\n6. Interoperability:
Blockchain technology enables the interoperability of different digital
assets and systems, allowing for seamless transfer and exchange of
value.\n\nOverall, the use of blockchain technology for managing digital
assets provides a secure, transparent, and decentralized system that is
accessible to anyone with an internet connection. This makes it an attractive
solution for managing various types of digital assets, including
cryptocurrencies, digital art, and other digital assets.',
'content_ms': 'Terdapat beberapa sebab mengapa orang menggunakan teknologi
blockchain untuk mengurus aset digital:\n\n1. Keselamatan: Teknologi
Blockchain menyediakan tahap keselamatan yang tinggi untuk mengurus aset
digital. Sifat blockchain yang tidak berpusat menyukarkan penggadam untuk
memanipulasi atau mencuri aset digital.\n2. Ketelusan: Blockchain menyediakan
rekod yang telus bagi semua transaksi yang berkaitan dengan aset digital. Ini
memudahkan untuk menjejak pemilikan dan mengesahkan ketulenan aset.\n3.
Kebolehcapaian: Teknologi Blockchain membolehkan pemindahan dan pengurusan
aset digital dengan mudah, menjadikannya boleh diakses oleh sesiapa sahaja
yang mempunyai sambungan internet.\n4. Ketidakbolehubahan: Setelah data
direkodkan pada rantaian blok, ia tidak boleh diubah atau dipadamkan. Ini
memastikan rekod pemilikan dan transaksi yang berkaitan dengan aset digital
adalah kekal dan tidak boleh diusik.\n5. Kebolehprograman: Teknologi
Blockchain membolehkan penciptaan kontrak pintar, yang merupakan kontrak yang
dilaksanakan sendiri dengan syarat perjanjian yang ditulis terus ke dalam
kod. Ini membolehkan pemindahan aset digital secara automatik dan selamat
berdasarkan syarat yang telah ditetapkan.\n6. Saling kendali: Teknologi
Blockchain membolehkan kesalingoperasian aset dan sistem digital yang
berbeza, membolehkan pemindahan dan pertukaran nilai yang lancar.\n\nSecara
keseluruhannya, penggunaan teknologi blockchain untuk mengurus aset digital
menyediakan sistem yang selamat, telus dan terpecar yang boleh diakses oleh
sesiapa sahaja yang mempunyai sambungan internet. Ini menjadikannya
penyelesaian yang menarik untuk mengurus pelbagai jenis aset digital,
termasuk mata wang kripto, seni digital dan aset digital lain.'}},
'filename': 'output-audio/1-0-0.mp3'}

```

The audio synthetic dataset and implementation published at [mesolitica/malaysian-youtube-audio-instructions](https://mesolitica.com/malaysian-youtube-audio-instructions/).

### 3 Synthetic Visual Malaysian Context Dataset

We gathered datasets that include images and captions, as detailed in the sources mentioned at [Multimodal Malaysian LLM dataset](#). We then generate synthetic instruction data based on image captions using a custom script as we parsed a JSON Lines file containing image captions.

Below are the script that we used to generate synthetic visual instructions:

```

chats = []
with open('motomalaysia-data.jsonl.translated') as fopen:
    for l in fopen:
        l = json.loads(l)
        overview = l['specs']['overview_translated']
        overview = [s for s in overview if s]
        overview = '\n'.join(overview)
        spec = '\n'.join(l['specs']['specs'])
        conversations = []
        conversations.extend([
            {"role": "user", "content": "<image>Ini model apa?"},
            {"role": "assistant", "content": l['specs']['model_name']},
        ])
        if len(overview):
            conversations.extend([
                {"role": "user", "content": "apa kelebihan moto tu?"},
                {"role": "assistant", "content": overview},
            ])
        conversations.extend([
            {"role": "user", "content": "apa spesifikasi moto tu?"},
            {"role": "assistant", "content": spec},
        ])
        chats.append({
            'image': l['local_image'],
            'image_url': l['img_url'],
            'conversations': conversations
        })

```

An example of generated dataset are as follow:

```

{
  "image": "pic/Yamaha NMAX (2016)_1.jpg",
  "image_url":
    "https://www.motomalaysia.com/wp-content/uploads/2017/10/yamaha-nmax-2.jpg",
  "conversations": [
    {
      "role": "user",
      "content": "<image>Ini model apa?"
    },
    {
      "role": "assistant",
      "content": "Yamaha NMAX (2016)"
    },
    {
      "role": "user",
      "content": "apa spesifikasi moto tu?"
    },
    {
      "role": "assistant",
      "content": "Manufacturer: Yamaha\nModel: 2016\nGeneration: Yamaha NMAX
        (2016)\n\nType: Scooter\nColour Available: Grey, Red\n\nDimension: 1,955
        x 740 x 1,115 mm\nWheelbase: 1,350 mm\nWeight: 136 kg\nSeat Height: 765
        mm\nGround Clearance: 135 mm\nMeter Display: Digital - Speedometer, Fuel
        Gauge\n\nEngine: 4-Stroke, SOHC\nDisplacement: 155 CC\nNo Of Cylinders:
        1-Cylinder\nCompression Ratio: 10.5 : 1\nBore x Stroke: 58mm x
        58.7mm\nMax Power: 11.1 kW @ 8,000 RPM\nMax Torque: 14.4 Nm @ 6,000
        RPM\nTransmission: Automatic, CVT\nClutch: Dry, centrifugal,
        Shoe\nIgnition System: Transistor Coil Ignition (TCI)\nStarting System:
        Electric Starter\nCooling System: Liquid Cooled\nFuel System: Fuel
        Injection\nFuel Capacity: 6.6 Liters\n\nFeatures:\nType: Underbone\nFront
        Suspension: Telescopic\nRear Suspension: Unit Swing\nFront Brake:
        Disc\nRear Brake: Disc\nFront Tire: 110/70-13\nRear Tire: 130/70-13"
    }
  ]
}

```

---

We designed a synthetic question-answering dialogues between assistant and a person about the photo. The answers are based on captions associated with the original data of the image.

The synthetic visual dataset and its implementation can be found on the HuggingFace Collections page under [Multimodal Malaysian LLM dataset](#).

## **4 Synthetic Multi-Images Multi-Audio relationship Dataset**

## **5 Synthetic Data Generation for Multi-Images, Multi-Audio Multi-turn Instructions**

We have observed that most open-source multimodal models accept only single images in individual multi-turn dialogues. These limitations make it difficult for people to further enhance the models.

To bridge these gaps, we aim to generate a multiple images, audio and dialogue turns that offers fine-grained interactions between multiple images, audio and words, mimicking user-assistant conversations.

By doing this approach, multimodal model would enhance its capabilities on understanding and reasoning across multiple images, audios and dialogue turns.

### **5.1 Synthetic Multi-Images Instruction**

### **5.2 Synthetic Multi-Audio Instruction**

### **5.3 Synthetic Image-Audio Instruction**

## **6 Finetuning Procedure**

MMModal aims to align visual and audio information from pretrained vision and audio encoders with an advanced large language model (LLM). We aim to bridge the gap between the visual and audio encoders and the LLM using a linear projection layer. To create an effective multimodal model, we followed a two-stage training approach exemplified by the works of [4–6] which have notably produced great results. In the initial stage, the model is pretrained on aligned image-text pairs and audio-text pairs to acquire knowledge of vision and audio language through the alignment projection layer. In the second stage, we fine-tune the pretrained model using a generated multiturn multiaudio images synthetic dataset, incorporating a designed conversational template to enable model comprehension on multi-images, multi-audio, and multi-images-multi-audio within a single multiturn session.

### **6.1 Overall Architecture**

---

### **6.2 Pretraining for Visual Feature Alignment**

During the initial pretraining stage, the primary objective is to equip the model with the ability to understand and generate language based on visual input. This is achieved through exposure to a diverse set of paired image-text data, where the model learns to associate visual information with corresponding textual descriptions. In our work, we utilize the pre-trained SigLip visual encoder to extract visual features for input into the projection layer. This projection layer facilitates the connection of image features into the text embedding space. The output of this projection layer then acts as the input to the Large Language Model, instructing it on how to generate appropriate textual responses based on the visual features provided. Only the linear projection layer is pretrained during the whole pretraining procedure; the pretrained vision encoder and the LLM stay frozen.

The implementation for visual feature alignment pretraining can be found [here](#)

### 6.3 Pretraining for Audio Feature Alignment

We also want to equip the model with the capability to comprehend and produce language from audio input. This is achieved by exposing the model to a diverse set of paired audio-text datasets, allowing it to learn the correspondence between audio features and corresponding textual descriptions. We utilize the pre-trained Whisper encoder to extract audio features for input into the projection layer. The injected projection layer plays a pivotal role in this process, serving as a bridge between the audio and text domains. The output of this projection layer serves as input to the Large Language Model, guiding it in generating appropriate textual responses based on the audio features provided. It is important to note that while the linear projection layer is trained throughout the entire pretraining procedure, the pretrained audio encoder and the Large Language Model remain static, or "frozen." This ensures that the model focuses specifically on learning the associations between auditory features and textual information without altering the underlying representations learned in the audio encoder or the language model.

The implementation for audio feature alignment pretraining can be found [here](#)

### 6.4 Instruction Finetuning

Following the initial pre-training alignment phase, the projection layer will be able to generate image and audio features that are effectively aligned with the pretrained Large Language Model text embedding space. However the pretrained LLM may still struggle to provide effective responses to human inquiries and may be unable to comprehend instructions involving multiple images, multiple audio files, and combinations thereof. To address this, we implement a second stage, utilizing the generated synthetic data to enhance performance and refine the alignment between audio, visual embeddings, the LLM, and instructions.

This stage involves fine-tuning the projection layer and the LLM on our collection corpus of generated synthetic data encompassing multiturn, multi-images and multi-audios data. The objective is to enable our multimodal model to process multiple inputs from images or audios and engage in multiturn conversation seamlessly. A significant advancement in our multi-image input capability stems from this fine-tuning procedure.

Throughout fine-tuning, we maintain the visual and audio encoder weights frozen while updating both the pre-trained weights of the projection layer and the LLM. Notably, we also incorporate a mechanism to replace image and audio embeddings based on the position of the image and audio tokens in the text embeddings, ensuring the model's ability to comprehend audio, image and text information effectively.

The hyperparameters involved in this finetuning stage are detailed below:

Hyperparameter	Value
DeepSpeed	ZeRO-2 Offload
Batch Size	12
Learning Rate	constant 2e-5
Precision	bfloat16

Complete fine-tuning 8192 context length implementation at [here](#).

## 7 Examples

This section presents examples that highlight the model's capacity to comprehend and produce responses relating to visual and audio input, showcasing the efficacy and potential of our proposed MModal. These examples clearly demonstrate how the model handles and combines various information modalities, including audio and pictures, in the context of natural language processing (NLP). MModal exhibits its capability by producing insightful, pertinent, and cohesive answers to a diverse set of inquiries. This highlights the model's capacity to create exceptionally efficient interfaces for human-machine communication.



---

### Multi Images Input Example

---



---

User	What is related between image 1 and image 2?
MMMModal	Nothing?

---

---

### Multi Audio Input Example

---

Audio 1 Transcription: anda tahu keuntungan boleh lebih tinggi daripada keuntungan kewangan rumah maka saya tidak akan mencari dalam akaun saya akan mencari ke dalam ethereum atau beberapa crypto punks bergantung pada faktor risiko anda kerana rumah kajang dihantar tidak mengganggu dsr saya sejauh ini jadi sekarang apa posisi saya untuk sekali lagi ia menyusahkan saya dan aset tetapi jika anda tidak selesa dengan mencari

Audio 2 Transcription: anda tahu keuntungan boleh lebih tinggi daripada keuntungan kewangan rumah maka saya tidak akan mencari dalam akaun saya akan mencari ke dalam ethereum atau beberapa crypto punks bergantung pada faktor risiko anda kerana rumah kajang dihantar tidak mengganggu dsr say lagi ia menyusahkan saya dan aset tetapi jika anda tidak selesa dengan mencari

---

User	What is related between audio 1 and audio 2?
MMMModal	Nothing?

---

## 8 Evaluation

## 9 Future Work

In our future endeavors, we aim to enhance our capabilities by focusing on several key areas. Firstly, we intend to refine our approach to generating synthetic datasets that incorporate multi-images and multi-audio inputs. This will involve expanding the dataset to include more complex relationships between inputs and facilitating comparisons involving more than two inputs. Additionally, we recognize the importance of incorporating a wider range of visual Malaysian context datasets into our model training pipeline. By diversifying our data sources, we can ensure that our model is equipped to handle a broader array of real-world scenarios and contexts, ultimately improving its performance and relevance in practical applications.

## 10 Acknowledgement

Special thanks to Malaysia-AI volunteers especially [Wan Adzhar Faiq Adzlan](#), [Ammar Azman](#), [M. Amzar](#), [Muhammad Farhan](#), [Syafie Nizam](#), [Halim Shukor](#), [Alif Aiman](#), [Azwan Zuharimi](#) and [Haziq Zikry](#) for contributing dataset to train MMMModal.



---

## Images Audio Input Example

---



Audio 1 Transcription: anda tahu keuntungan boleh lebih tinggi daripada keuntungan kewangan rumah maka saya tidak akan mencari dalam akaun saya akan mencari ke dalam ethereum atau beberapa crypto punks bergantung pri itu saya boleh membayar perbezaan dengan menggunakan wang ini kerana sekali lagi ia menyudahkan saya dan aset tetapi jika anda tidak selesa dengan mencari

User

What is related between audio 1 and image 2?

MMModal

Nothing?

---

We would like to express our gratitude to NVIDIA Inception for generously providing us with the opportunity to train our model on the Azure cloud. Their support has played a crucial role in the success of our research, enabling us to leverage advanced technologies and computational resources.

We extend our thanks to the wider research community for their valuable insights and collaborative discussions, which have greatly influenced our work. This paper reflects the collective efforts and contributions from both NVIDIA Inception and the broader research community.

## 11 Conclusion

In this paper, we introduce MModal, a multimodal instruction tuned Model (LLM) specifically designed to handle multiple modalities, including images, audio, and text in a multi-turn dialogue setting. Our novel approach focuses on aligning representations from various modality encoders into a unified space. Unlike existing methods, our model effectively able to process multi-turn dialogues and incorporate multiple images or audio inputs in its responses. We provide examples demonstrating the multi-modal understanding capabilities of MModal.

## References

- [1] Chenyang Lyu, Minghao Wu, Longyue Wang, Xinting Huang, Bingshuai Liu, Zefeng Du, Shuming Shi, and Zhaopeng Tu. Macaw-llm: Multi-modal language modeling with image, audio, video, and text integration, 2023.
- [2] Haotian Liu, Chunyuan Li, Qingyang Wu, and Yong Jae Lee. Visual instruction tuning, 2023.
- [3] OpenAI, :, Josh Achiam, Steven Adler, Sandhini Agarwal, Lama Ahmad, Ilge Akkaya, Florencia Leoni Aleman, Diogo Almeida, Janko Altschmidt, Sam Altman, Shyamal Anadkat, Red Avila, Igor Babuschkin, Suchir Balaji, Valerie Balcom, Paul Baltescu, Haiming Bao, Mo Bavarian, Jeff Belgum, Irwan Bello, Jake Berdine, Gabriel Bernadett-Shapiro, Christopher Berner, Lenny Bogdonoff, Oleg Boiko, Madelaine Boyd, Anna-Luisa Brakman, Greg Brockman, Tim Brooks, Miles Brundage, Kevin Button, Trevor Cai, Rosie Campbell, Andrew Cann, Brittany Carey, Chelsea Carlson, Rory Carmichael, Brooke Chan, Che Chang, Fotis Chantzis, Derek Chen, Sully Chen, Ruby Chen, Jason Chen, Mark Chen, Ben Chess, Chester Cho, Casey Chu, Hyung Won Chung, Dave Cummings, Jeremiah Currier, Yunxing Dai, Cory Decareaux, Thomas Degry, Noah Deutsch, Damien Deville, Arka Dhar, David Dohan, Steve Dowling, Sheila Dunning, Adrien Ecoffet, Atty Eleti, Tyna Eloundou, David Farhi, Liam Fedus, Niko Felix, Simón Posada Fishman, Juston Forte, Isabella Fulford, Leo Gao, Elie Georges, Christian Gibson, Vik Goel, Tarun Gogineni, Gabriel Goh, Rapha Gontijo-Lopes, Jonathan Gordon, Morgan Grafstein, Scott Gray, Ryan Greene, Joshua Gross, Shixiang Shane Gu, Yufei Guo, Chris Hallacy, Jesse Han, Jeff

Harris, Yuchen He, Mike Heaton, Johannes Heidecke, Chris Hesse, Alan Hickey, Wade Hickey, Peter Hoeschele, Brandon Houghton, Kenny Hsu, Shengli Hu, Xin Hu, Joost Huizinga, Shantanu Jain, Shawn Jain, Joanne Jang, Angela Jiang, Roger Jiang, Haozhun Jin, Denny Jin, Shino Jomoto, Billie Jonn, Heewoo Jun, Tomer Kaftan, Łukasz Kaiser, Ali Kamali, Ingmar Kanitscheider, Nitish Shirish Keskar, Tabarak Khan, Logan Kilpatrick, Jong Wook Kim, Christina Kim, Yongjik Kim, Hendrik Kirchner, Jamie Kiros, Matt Knight, Daniel Kokotajlo, Łukasz Kondraciuk, Andrew Kondrich, Aris Konstantinidis, Kyle Kopic, Gretchen Krueger, Vishal Kuo, Michael Lampe, Ikai Lan, Teddy Lee, Jan Leike, Jade Leung, Daniel Levy, Chak Ming Li, Rachel Lim, Molly Lin, Stephanie Lin, Mateusz Litwin, Theresa Lopez, Ryan Lowe, Patricia Lue, Anna Makanju, Kim Malfacini, Sam Manning, Todor Markov, Yaniv Markovski, Bianca Martin, Katie Mayer, Andrew Mayne, Bob McGrew, Scott Mayer McKinney, Christine McLeavey, Paul McMillan, Jake McNeil, David Medina, Aalok Mehta, Jacob Menick, Luke Metz, Andrey Mishchenko, Pamela Mishkin, Vinnie Monaco, Evan Morikawa, Daniel Mossing, Tong Mu, Mira Murati, Oleg Murk, David Mély, Ashvin Nair, Reiichiro Nakano, Ramee Nayak, Arvind Neelakantan, Richard Ngo, Hyeonwoo Noh, Long Ouyang, Cullen O’Keefe, Jakub Pachocki, Alex Paino, Joe Palermo, Ashley Pantuliano, Giamattista Parascandolo, Joel Parish, Emy Parparita, Alex Passos, Mikhail Pavlov, Andrew Peng, Adam Perelman, Filipe de Avila Belbute Peres, Michael Petrov, Henrique Ponde de Oliveira Pinto, Michael, Pokorny, Michelle Pokrass, Vitchyr Pong, Tolly Powell, Alethea Power, Boris Power, Elizabeth Proehl, Raul Puri, Alec Radford, Jack Rae, Aditya Ramesh, Cameron Raymond, Francis Real, Kendra Rimbach, Carl Ross, Bob Rotsted, Henri Roussez, Nick Ryder, Mario Saltarelli, Ted Sanders, Shibani Santurkar, Girish Sastry, Heather Schmidt, David Schnurr, John Schulman, Daniel Selsam, Kyla Sheppard, Toki Sherbakov, Jessica Shieh, Sarah Shoker, Pranav Shyam, Szymon Sidor, Eric Sigler, Maddie Simens, Jordan Sitkin, Katarina Slama, Ian Sohl, Benjamin Sokolowsky, Yang Song, Natalie Staudacher, Felipe Petroski Such, Natalie Summers, Ilya Sutskever, Jie Tang, Nikolas Tezak, Madeleine Thompson, Phil Tillet, Amin Tootoonchian, Elizabeth Tseng, Preston Tuggle, Nick Turley, Jerry Tworek, Juan Felipe Cerón Uribe, Andrea Vallone, Arun Vijayvergiya, Chelsea Voss, Carroll Wainwright, Justin Jay Wang, Alvin Wang, Ben Wang, Jonathan Ward, Jason Wei, CJ Weinmann, Akila Welihinda, Peter Welinder, Jiayi Weng, Lilian Weng, Matt Wiethoff, Dave Willner, Clemens Winter, Samuel Wolrich, Hannah Wong, Lauren Workman, Sherwin Wu, Jeff Wu, Michael Wu, Kai Xiao, Tao Xu, Sarah Yoo, Kevin Yu, Qiming Yuan, Wojciech Zaremba, Rowan Zellers, Chong Zhang, Marvin Zhang, Shengjia Zhao, Tianhao Zheng, Juntang Zhuang, William Zhuk, and Barret Zoph. Gpt-4 technical report, 2023.

- [4] Deyao Zhu, Jun Chen, Xiaoqian Shen, Xiang Li, and Mohamed Elhoseiny. Minigpt-4: Enhancing vision-language understanding with advanced large language models, 2023.
- [5] Yucheng Han, Chi Zhang, Xin Chen, Xu Yang, Zhibin Wang, Gang Yu, Bin Fu, and Hanwang Zhang. Chartllama: A multimodal llm for chart understanding and generation, 2023.
- [6] Yuliang Liu, Zhang Li, Biao Yang, Chunyuan Li, Xucheng Yin, Cheng lin Liu, Lianwen Jin, and Xiang Bai. On the hidden mystery of ocr in large multimodal models, 2024.