AI RESEARCH AND DEVELOPMENT PROJECTS (SEM2 AF-2023/4) 55-708252-AF-20234

AI-Enhanced Equestrian Jump Analysis System

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1. Problem description

When horses jump over obstacles, lots of parameters are intertwined to assess their performance and score. These parameters are depended on many factors, including the count of strides that are taken between obstacles, how the meticulous positioning of their legs is before and after each jump, any touch or knocking down poles on obstacles throughout the course, the adept handling of the reins by the rider, and even whether a horse is a right-handed or left-handed. Our esteemed client, British equestrian, use the combination of manual annotation and sophisticated software tools such as Dartfish to meticulously document these parameters and generate .csv files from them.

This advantageous collected data is applied to train horses for enhancing their performance in competitive arenas with a dual objective of minimizing injuries and maximizing scores during championship events.

Although analyzing all these parameters is carried out by human analysts within the equestrian team, some challenges emerge in there. The inevitability of human errors, time-consuming and potentially inefficient, incurring significant costs are the most important issues. Moreover, unpredictable factors such as varying camera angles, shadows, and the pace of action occasionally affect the precise discernment of these crucial parameters.

2. Solution implemented and Justification

Our approach involves designing an AI-enhanced system developed to be efficient, reliable, and robust to assist coaches and athletes by tracking and analysing the equestrian performances across multiple variables. This system comprehensively evaluates all engaged parameters with details due to horse actions. By leveraging these analyses, team leaders can improve their expertise to get better scores in championships.

Selenium automation is employed to download all video clips and csv files were included, from Dartfish website (British Showjumping, n.d.) which was shared by client. First, we used those videos to figure out how the horse got score while jumping and overtake the obstacles. Subsequently, we decided to break down the issues (csv columns) into separate ones and tackle them sequentially. For our first step, we tried to clarify which jump is clear one. We split video clips into around one and half second and that is exactly when the jumping is happening and divided them into clear and fail jump in separate folders.

Initially, we explore MediaPipe to detect horse poses. It is a tool introduced by Google, we tried to detect and track fingers, hands, and face (Hand landmarks detection guide, n.d.). We found out with help of this tool we could be able to detect objects, recognize gestures and much more. But it is Inefficient when it comes to the scenarios that involving multiple horses or obstacles.

To overcome this and boost in detection horses and riders we employed YOLO v8 (Explore Ultralytics YOLOv8, n.d.) (Felipe, 2023) (Ultralytics YOLOv8 Docs, n.d.). It is fast and perfect for detecting objects

in photos or videos even if many different objects are engaged. We used to pass videos through the model, and it could detect horses and riders perfectly. Although while proficient at detecting horses in images, YOLO v8 lacks suitability for video training. We needed to classify which jump is correct or not. Therefore, we turn to recurrent neural network (RNN) models, which possess memory capabilities, essential for tracking sequences of events:

1. OmniMotion: Tracking Everything Everywhere All at Once method can track motion accurately for every pixel in a video (Qianqian Wang, Yen-Yu Chang, Ruojin Cai, Zhengqi Li, Bharath Hariharan, 2023) (Wang, Q., Chang, Y. Y., Cai, R., Li, Z., Hariharan, B., Holynski, A., & Snavely, N, 2023). One of our potential challenges is when horses or some part of them get hidden by obstacles, shadows, or any noises, in such cases OmniMotion can improve our accuracy in detecting horses and obstacles. We found out it was not working well with thin and tiny objects like poles on the obstacles in our case.
2. MMAction2: it is a model which can understanding and analysing videos and designed for recognition actions and activities in videos. We train the model with our split videos to classify jumps. However, our result was not appropriate it got 54 percentage of accuracy. (WELCOME TO MMACTION2'S DOCUMENTATION, 2020)
3. Combination of CNN and RNN: Convolutional Neural Network is like a clever brain that works like our eyes. It is like a puzzle solver, breaks the picture into small parts and check each part to see what it is in there. With the aid of this model in our project we extracted features from videos frame by frame. Recurrent Neural Network due the memory that it has, like a smart person who remember everything that you have told them before. So, it will be work great for sequence of things like words, voices, and videos.

   We tried the combination of these two AI models to get result. (Paul, 2021) (Singla, 2022) Unfortunately, the results were frustrating for us. It gave us 59 percentage of accuracy as the output.
4. 3DCNN: it likes a super smart brain which is great to understand patterns and features of objects in three dimensions space (height, width, and depth). It helps to have better detecting and tracking moving objects and classifying them. (Tran, D., Wang, H., Torresani, L., Ray, J., LeCun, Y., & Paluri, M., 2018) We trained this model with 50 epochs on over three hundred videos for each clear and uncleared one. (Video classification with a 3D convolutional neural network, n.d.) It got better result, achieving a 69 percentages accuracy rate, surpassing previous attempts.

Due to analysing the accuracy and lost graphs of these models, we preprocessed the data again. We segmented horse, rider, and in addition auto-annotated obstacle elements using the YOLO model with Roboflow dataset (Equestrian-AI, 2024). Background noise is reduced by the Selective Attention Mechanism (SAM) applied to the YOLO v8 model (Ariuntuya, 2023). By focusing on these specific elements, our models will show a significant improvement in accuracy in jump classification.

3. Contribution log

Week No.	Task & Description	My Contribution (Percentage)	Others Contribution (Percentage)	Time spending			Outcomes & Explanation
				Start Date	End Date	Hours	
1	Programming: Preliminary research on Equestrian sports, and video classification algorithms	60	40	01/02/2024	07/02/2024	16	Implement MediaPipe, Questions for supervisor regarding AI methods - Clarity & head-start on AI algorithms
2	Programming: Preliminary implementation of video classification algorithms	50	50	08/02/2024	14/02/2024	14	Test Yolo, Questions for supervisor regarding AI methods - Clarity on Yolo, questions regarding dataset & csv files
3	Project Management & Documentation: Update Trello/GitHub, record meeting minutes, analyse data & develop AI implementation strategy	30	70	15/02/2024	21/02/2024	7	Questions & update for scrum meeting, resource management & data cleaning plan - Defining preprocessing techniques in coordination with supervisor, push for data gathering
4	Research & Documentation: Research on AI algorithms for detection & segmentation in video frames, record meeting minutes	50	50	22/02/2024	28/02/2024	8	Initial most suitable AI model for training on videos, questions for scrum meeting - Initial YoloV8 model for training on videos
5	Research & Documentation: Research on video classification methods	60	40	29/02/2024	06/03/2024	26	CNN+RNN initial workings - An initial code from GitHub & YouTube for video classification
6	Programming: Implement CNN+RNN	60	40	07/03/2024	13/03/2024	25	Evaluate results of complete code funnel (preprocessing + training), fine tuning - First baseline AI model for action recognition
7	Programming: Implement 3DCNN	60	40	14/03/2024	20/03/2024	30	Debug, Evaluate, Finetune 3D-CNN - New baseline model
8	Project Management / Monitoring & Evaluation: Update meeting records, document progress & contribution logs	33	66	21/03/2024	27/03/2024	6	Update supervisor & client, resolve stuck results - Pivot strategy & choose videos with good angles
9	Programming: Implementation of YoloV8 on Roboflow Dataset, Learning about MMAction2	20	80	28/03/2024	03/04/2024	10	Successfully detect obstacles, Auto-Annotation Obstacels
10	Project Management / Monitoring & Evaluation: Evaluation models, Update logs & dashboards, record meeting minutes	40	60	04/04/2024	10/04/2024	10	Evaluate models and analyse graphs for prediction accuracy, Updated project documents - Monitor project progress & alignment
11	Programming: Lerning and Implementing slowfast & detectron2	60	40	11/04/2024	17/04/2024	12	Obtain detected & segmented obstacle + horse - Unsuccessful(It was not segment the obstacles)
12	Research & Documentation: Create presentation content & support in programming, Investigate and Evaluate datasets and low accuracy of AI Models	40	60	18/04/2024	24/04/2024	10	PowerPoint content & reference videos - Collaborate on presentation & assist in programming
13+	Documentation: Writing individual reports and Upload codes into GitHub	100	0	25/04/2024	07/05/2024	10	Created individual report, Code explanation and uploaded clean code

4. Personal Reflection

Rotation tasks are indeed pivotal to our project's success. By dividing tasks and rotating them we aim to gain the maximum knowledge of all aspects of the project in a collaborative environment. These tasks, split into three main categories of research and documentation, project management and programming. Each week team members were responsible for one category; it enabled us to dive deeply into the aspects.

Within the research and documentation part, we focused on studying and exploring various academic papers, methodologies, and models relevant to our project's challenges. In analyzing the problem and challenges I believe we worked great. We tried to analyze every video in detail to discover the best solution for them. For instance, our efforts in preprocessing data, we tried to split videos into exact jump timestamps, leading us to successful outcomes.

Effective communication was applied in our team. Using a variety multimedia and social media platforms such as Microsoft teams, Google drive, WhatsApp, and GitHub to ensuring information exchange. Additionally, due to keep updating the team about our duties, we had weekly online and in-person meetings.

My working with virtual machines through Microsoft Azure has been a new opportunity to play around and learn more about Azure. Furthermore, programming in Jupyter Notebook environment for models training has been pleasurable and rewarding experience for me. Despite my previous experience in using traditional pen-and-paper methods and offline platforms for project management, I have learned applied online and cloud-based tools like Trello in project management that is designed for such thing purposes. Moreover, diving deeper into risk management and learning about how I could overcome multiple and unpredictable risks whenever our group got in trouble, specifically in time management.

In the term of image processing and segmentation, I learned and applied a variety of cutting-edge methods that can be used for them. Hands-on experimentation and analyzing their codes, enhance my abilities in programming and modification of the AI models' layers.

About future projects, I can use all the experiences that I gain from the project in the module. choosing an online or cloud-based project manager platform which is accessible for all the group members leads groups to be more active and collaborative. Regular client meetings are another important factor for moving projects forward. It provides these opportunities to clarify requirements and issues for having a comprehensive understanding around the problems and having the whole idea about the start point project.

Documentation and keeping it updated is another crucial aspect in the process of implementation, specifically in team working projects. For instance, if a member of a group encounters trouble during a project, or even gets fired or leaves the project, the substitute member could review the project status and the timeline and continue the process. Furthermore, time planning and schedule, effectively enabling team members to get a better view of project milestones.

Utilizing communication platforms to get in touch with other members must be considered. Platforms, specifically the ones that have shared space environments for sharing the codes, ideas, documentations, meeting points and all the matters around the project are preferable. This integrated platform not only enhances project oversight but also empowers project managers to effectively coordinate tasks and resources.

5. Peer Contribution Form

How equal (or not) was each team member's contribution, including yourself, in your opinion?

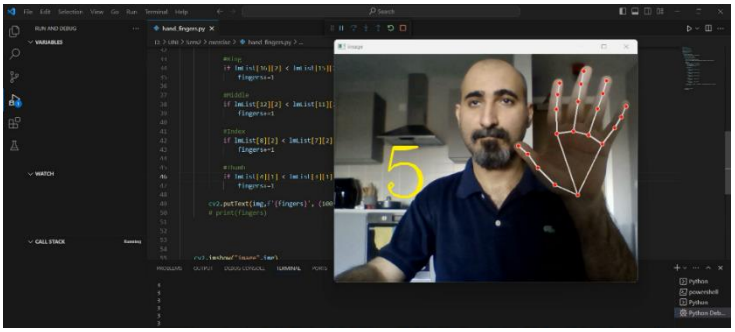
For example:

- A team where all members contributed equally, consisting of 3 people, each person would get the same mark, so each contribution is exactly 33%.
- A team where one member did most of the work, consisting of 3 people, so one person gets 70% and the other two get 15% each.

Group Name: Group 3 **Your name: Siavash Mortaz Hejri**	
Names of ALL members of the group.	**Contribution** **(should add up to 100)**
1. Siavash Mortaz Hejri	33
2. Ammar Ali	33
3. Javeria Munir	33
Total	**100/100**

Please discuss why you think this share of contribution is appropriate below. Don't forget to cover your own work (only briefly):

Due to my background in programming, I had experience in coding and working with algorithms, however I was not very skillful in project management and documentation. With the aim of rotation of those tasks weekly, I could cover all aspects of the project during this module. Furthermore, I transfer my experience and knowledge to the other members of our group. It was a great opportunity for me to gain experience in mentoring. Javeria has a good background in project management, so she passed her experience on to us, and I used the knowledge that I kept from her to apply in the project in the week that I was as project manager leader. Ammar another member of the group was great at research and find latest methods for our project and knowing how documentation the project. We used his work to boost our project process. He taught us his knowledge and we could use it whenever it was our turn for documentation and research tasks.



In my side as programmer, first I was exploring MediaPipe. Although it was supposed to be a method for detecting horses' joints, it did not work very well with horses in video clips specifically when it comes to multiple horses within a video. I read a bit about OmniMotion method which can track every pixel everywhere even behind obstacles. Then I researched other methods to detect and segment horses in videos, I watched tutorials from YouTube to learn about YOLO models for detecting and segmenting horses in the videos. In meanwhile, some idea about how process images and videos popped in my head. My idea was using Convolutional models that we studied previous semester. So, I tried to read more about CNN models and play around with them. Moreover, from my previous semester study, I knew that for the sequence frames I needed to integrate CNN model to RNN model. It had some results, but they were not very great. Then I tried another model called 3DCNN that was like CNN which processing images in 3 dimensions. For training these models the GPU and CPU resources in Google Colab were too limited and was time consuming. For improving the speed of the training and processing models I used the Virtual machines within Microsoft Azure which was accessible for me through my university account. I was a great opportunity for me to working with Linux command to instead GitHub in there and coding through Jupyter Notebook environment.

As project management, I used Trello and Excel sheets to manage time and resources for other members. I moderated in-person and online meetings in groups and took notes and kept it updated whether it was scrum meeting with the client and supervisor or interior group meeting.

In conclusion, I believe this rotation contribution had many advantages for me to gain new experience and knowledge to overcome challenges in the project from different views.

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