Drafts of Year 2 Project

Version1.0	4 Dec 2022	First uploading by Yixiao Shen.
Version2.0	1 Feb 2023	Add the schedule for first 2 weeks.

1 Key Words

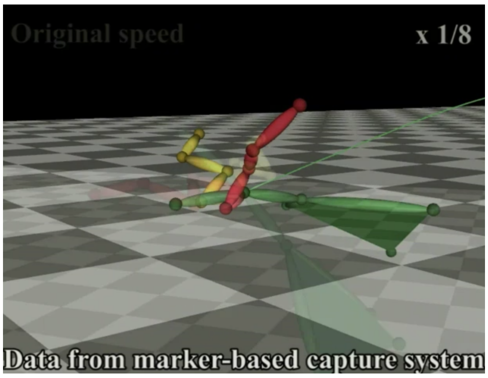
non-optical bio-logging system, digital twin, wearable sensor system, webGPU, AHRS, IMU

2 Missions

1. Project allocation
   (a) Risk assessment form [Due 15 Dec]
   (b) Ethical approval form [Due 15 Dec]
   (c) Component ordering form
      i. Onecall (http://onecall.farnell.com)
      ii. CPC (http://cpc.farnell.com)
      iii. Farnell (http://uk.farnell.com)
      iv. Rapid (http://www.rapidonline.com)
      v. RS (http://uk.rs-online.com)
2. Bench Inspection [Due 2-3 March 2023][in Week 5]
   (a) Blog
   (b) Poster
   (c) Weekly log-book
   (d) Project management forms
      i. Role allocation (responsibility matrix).
      ii. Contribution to project deliverables.
      iii. Attendance record.
      iv. Supervisor weekly meeting log.
3. Project report [Due 17 March 2023][in Week 7]

3 System Decomposing

3.1 Stage 0: Bird Wing Structure (left out temporarily)



(a) Joints modeling

(b)

Figure 1: Two sample screenshots [1] for digital twin via a optical motion capture system.

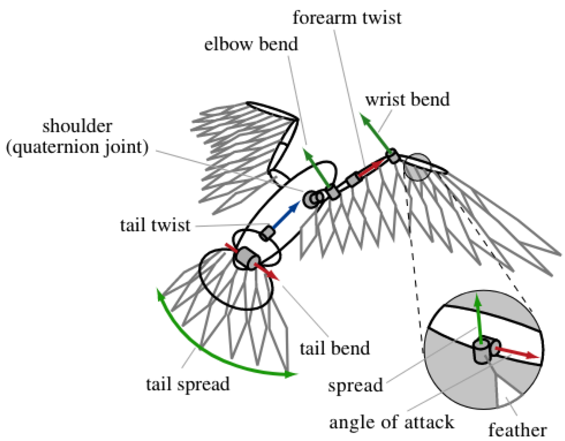


Figure 2: Another bird skeleton for modeling purpose [2].

To be continued. . . But one feature is for sure: there are lots of joints to model, moving the analysis to the next stage.

3.2 Stage 1: Multiple Joints

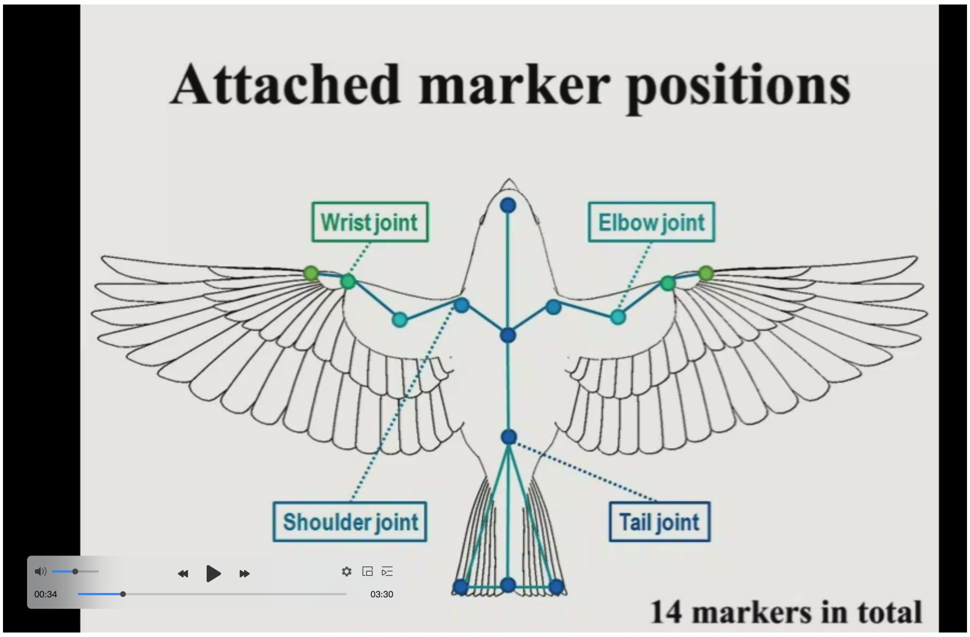


Figure 3: Attached marker positions for optical bio-logging system [1], including shoulder, elbow, wrist and tail recordings (240fps). The motion of feathers was also observed by four high speed cameras (1000fps). Proportional Derivative (PD) control approach was used to link two adjacent states detected by the Vicon system.

Figure 3 has demonstrated a data-driven bird simulation through a Vicon optical motion capture system via 14 markers. However, the drawback of such system is the environment limitation since all cameras only focused on a $14 \times 16 \times 7(m)$ area.

Hence, one more adaptive method for motion capture is using inertial systems, which requires multiple Inertial Measurement Units (IMUs) to be installed on the target. Given that both motion capture systems have to simulate the model of birds into the monitor, those joints indicated in Figure 3 can be also applied in our Year 2 Project. Therefore, we can limit our attention to stage 2: a simple joint, which will be a basic demo/function. After that, we may try extending it to a more complected target.

3.3 Stage 2: A Simple Joint

This stage is mainly about logging the motion of one stick installed with an accelerometer (or with a gyro sensor more). Specifically, we aim to display its movements into the monitor. Discussions will be seperated into hardware and software two parts.

3.3.1 Hardware Process

Main components:

1. IMU 3DOF/6DOF/9DOF Board (IIC/SPI interface)
2. Microcontroller including AHRS lib
3. Power supply.

Procedures

1. Sensor calibration & compensation
2. Transform raw data to roll&yaw&pitch using a AHRS lib
3. Send the data package to PC via Virtual Serial Port, which has a high speed

3.3.2 Software Process

Software Tools:

1. Browser with WebGPU/WebGL API: three.js

Procedures: modeling & displaying

1. Create a cuboid in https://threejs.org/editor/.
2. Make a point static and lock the shape.
3. Link the position of another point to an input file, which stores the coordinates of points.

Procedures: data processing

1. Receive roll&yaw&pitch data from the microcontroller.
2. Format&interpolate the data to the file for modeling.

4 Schedule

Below is a draft schedule for the first two weeks, namely developing hardware and software separately. If successful in these two weeks, we will then combine the two systems together and test it in the last two weeks. Our lab location is **ROOM302, 7A-7D**.

4.1 Week-1 & Week-2

4.1.1 Hardware System

Table 1: Task allocation for hardware system in the first two weeks

<table>
<tr><th></th><th>Compulsory Task</th><th>Optional Task</th></tr>
<tr><td>Brissenden, Jack</td><td rowspan="2">T0, T1, T2</td><td rowspan="2">T4(not-yet-decided)</td></tr>
<tr><td>Guo, Jiajun</td></tr>
<tr><td>Canning, Charles Thomas</td><td>T3</td><td>T0, T1, T2</td></tr>
</table>

Task-0: pre-work [EASY]

1. collect & check the components.
2. prepare cables for linking.

Task-1: single IMU [EASY]

Table 2: Time-schedule for T1-“single IMU”

Early-finish-date	Thursday Evening of W1
Late-finish-date	Friday Evening of W1

1. construct one circuit with only one IMU, excluding IIC multiplexer.
2. initialize the IMU (if not) !
3. fetch data from this single IMU and then convert them into roll/yaw/pitch (if needed), output them in the terminal.

Figure 4: Output format for T1

Task-2: multiple IMUs [Half-difficult]

1. construct the circuit including the IIC multiplexer, namyly multiple IMUs.

Table 3: Time-schedule for T2-“multiple IMUs”

Early-finish-date	Friday Evening of W1
Late-finish-date	Monday Morning of W2

2. initialize the IMUs (if not)!
3. fetch data from those IMUs and then convert them into roll/yaw/pitch (if needed), output them in terminal with their corresponding IMUs’ index.

```
IMU-1
    ROLL:
    YAW:
    PITCH:
IMU-2
    ROLL:
    YAW:
    PITCH:
IMU-3
    ROLL:
    YAW:
    PITCH:
...
```

Figure 5: Output format for T2

TASK-3: communicate with PC using Berkeley Socket [Difficult] [Primary-Plan]

Table 4: Time-schedule for T3-“Berkeley Socket”

Early-start-date	Thursday of W1
Late-start-date	Friday of W1
Early-finish-date	Wednesday of W2
Late-finish-date	Monday of W3

1. Board Type: Arduino-WIFI-Rev2.
2. support sending HTTP-POST request.

TASK-4: communicate with PC using USART [Half-difficult] [Backup-Plan for TASK-3]

Table 5: Time-schedule for T4-“USART”

Start-date	not-yet-decided
End-date	not-yet-decided

1. Board Type: Arduino-Nano.
2. support USART transmitting.

4.1.2 Software System

Table 6: Task allocation for software system in the first two weeks

	Compulsory Task	Optional Task
Shen, Yixiao	T1, T2	T3(not-yet-decided)
Zhou, Qi	T1, T2	T3(not-yet-decided)

TASK-1: build a simple socket server using C++ on LinuxOS. [EASY] [Half-completed]

1. support responding HTTP-GET request. [Bug: missing of MIME Type]
2. support forward one message from one client(Arduino) to another client(browser). [Wait for Hardware-TASK-3]
3. support responding HTTP-POST request. [Wait for Hardware-TASK-3]

TASK-2: build a simple displaying engineer using three.js on Web, namely HTML&CSS&JS.

Table 7: Time-schedule for T2-"displaying engineer"

Early-finish-date	Monday morning of W2
Late-finish-date	Friday of W2

1. bind joints model with their corresponding IMUs. [Difficult] [Need more discussion] need more discussions here.
2. support input from server. [Interface defined]

TASK-3: support serial port communication. [Half-Difficult] [Backup-Plan for Hardware-TASK-3]

Table 8: Time-schedule for T3-"serial port"

Start-date	not-yet-decided
Finish-date	not-yet-decided

5 Relevant Articles

1. A optical bio-loggers for birds [1].
2. A simple 3-axial accelerometer bio-loggers for birds [3].
3. A simple 3-axial accelerometer bio-loggers for cats [4].
4. A simple 3-axial accelerometer bio-loggers for imperial cormorants [5].
5. Leonardo da Vinci's discovery of the dynamic soaring by birds in wind shear [6].
6. Wind Energy Extraction by Birds and Flight Vehicles [7].
7. Automatically generating holograms via accelerators [8].

References

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[2] J.-c. Wu and Z. Popovic, "Realistic Modeling of Bird Flight Animations," p. 8, 2003.

[3] L. A. Taylor, G. K. Taylor, B. Lambert, J. A. Walker, D. Biro, and S. J. Portugal, "Birds invest wingbeats to keep a steady head and reap the ultimate benefits of flying together," *PLoS Biol*, vol. 17, no. 6, p. e3000299, Jun. 2019. [Online]. Available: https://dx.plos.org/10.1371/journal.pbio.3000299

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