Jansen's Pet: Design of a Remote-Controlled Steerable Mechanical Walker

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Executive Summary

The Jansen's Pet is a steerable two-legged mechanical walker, capable of being remote controlled via infrared signal

- Overall controls facilitated by Arduino UNO
  - Uses an IR receiver for IR remote control
- Uses a DC Gearmotor for Jansen style leg mechanism actuation
- Uses a servo motor for bell crank steering control
- Battery powered by 12V lithium ion battery pack
- The team referenced the book "Design of Mechanical Walking Robots" to improve on preexisting designs[1]

Chassis

- Two legged Dachshund walker
  - Steerable
  - Walks well forward & backwards
  - 15.4 x 8.3 x 4.5 inches
- Laser cut Baltic Birch Plywood

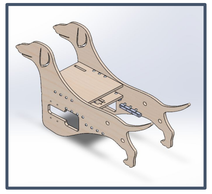


Fig 1. Assembled Chassis

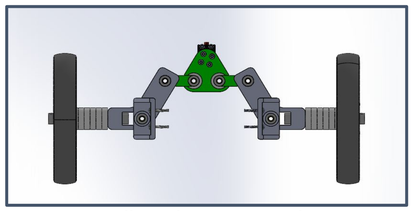


Fig 2. Bell Crank Steering Mechanism

Steering Mechanism

- Bell crank
  - Feasible, simple, reliable
  - Manufactured by 3D printing
  - Laser cut acrylic

Leg Mechanism

- Jansen style leg mechanism
  - Original: 11 linkages generating smooth walking motion
  - Parallelogram makes leg susceptible to singularities ⇒ mechanism may collapse into itself
- Solution: Jansen leg with belt drive
  - Provides a hard stop ⇒ eliminates singularity
- GeoGebra
  - Convenient tool that helps design mechanism
    - Scales image to obtain appropriate dimensions for linkages & joints

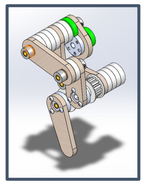


Fig 6. Isometric View of Jansen Leg

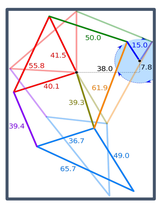


Fig 3. Jansen's Linkage (Wikipedia)

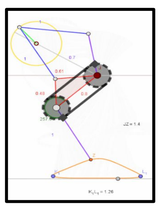


Fig 4. Jansen Leg with Belt Drive (Geogebra)

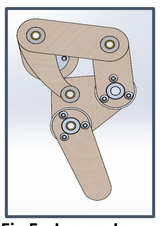


Fig 5. Jansen Leg with Belt Drive (SolidWorks)

Power Train

- Single drive motor for leg on both sides
  - Laser cut gears transfers rotational motion from motor to crank
- Servo motor for steering mechanism
  - Servo horn connected to linkages & pivots
  - Secured with brackets

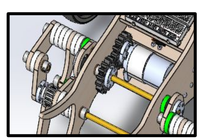


Fig 7. Drive Motor with Gears

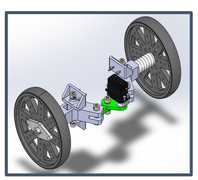


Fig 8. Isometric View of Steering Subassembly

Jansen's Pet

Fig 9. Team Logo

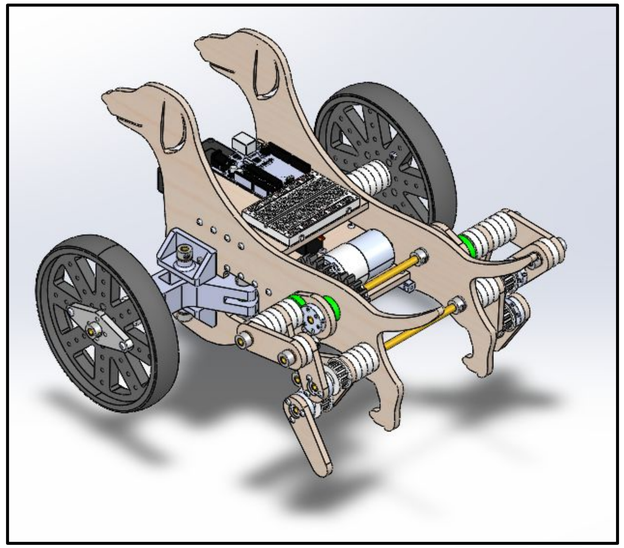


Fig 10. Isometric View of Full Assembly

Electronics

- Arduino UNO R3
- IR controlled
- Battery powered
- DC Motor for leg mechanisms
- Servo Motor for steering

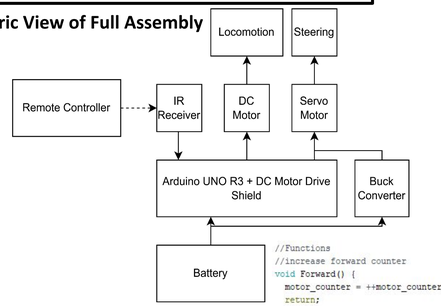


Fig 11. General Wiring Diagram

Software

- Arduino IDE

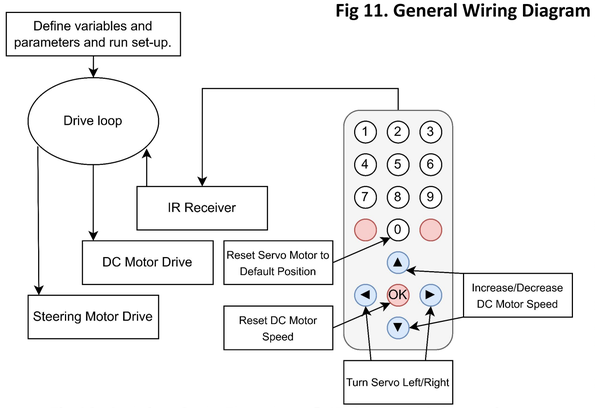


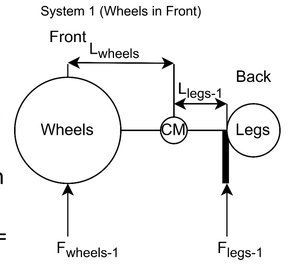
Fig 12. Arduino Code Flowchart & IR Controls Schematic

```
//Functions
//increase forward counter
void Forward() {
  motor_counter = ++motor_counter;
  return;
}

//decrease forward counter
void Backwards() {
  motor_counter = --motor_counter;
  return;
}

//increase servo motor counter
void Right() {
  servo_counter = ++servo_counter;
  return;
}

//decrease servo motor counter
void Left() {
  servo_counter = --servo_counter;
  return;
}

//stop motors
void Stop() {
  motor_counter = 0;
  return;
}

//Recenter servo
void Center() {
  servo_counter = 0;
  return;
}
```

Fig 13. Snapshot of Arduino Code

Engineering Analysis

- Reasoning for putting wheels in the front (and not on the back)
  - Leg touches the ground first closer to center of gravity
  - Smaller moment arm = Larger force
  - Larger normal force = More friction
  - Legs provide more push force
- Motion Analysis
  - Analyzes motion of full assembly
  - Simulates how well physical prototype will walk



Taking the moment about the center point of the wheels for both systems,

$F_g L_{wheels}=F_{legs-1}(L_{wheels}+L_{legs-1})$ $F_g L_{wheels}=F_{legs-2}(L_{wheels}+L_{legs-2})$

$F_{legs-1}(L_{wheels}+L_{legs-1})=F_{legs-2}(L_{wheels}+L_{legs-2})$

$L_{legs-1}<L_{legs-2}$, so $L_{wheels}+L_{legs-1} < L_{wheels}+L_{legs-2}$

$\therefore F_{legs-1}>F_{legs-2}$

$\mathbf{f_1=\mu F_{legs-1}>f_2=\mu F_{legs-2}}$

Fig 14. Statics Analysis Comparison (at the instant that the leg first hits the ground): Wheels in Front vs Wheels on the back

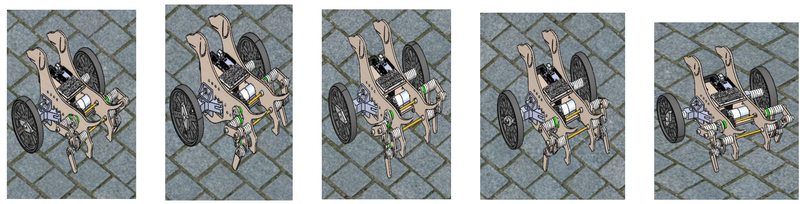


Fig 15. Snapshots of Motion Analysis in One Second Intervals

Hardware Performance

- Prototype build is in-progress, although it should be done by Week 10
- Electronics have been tested by itself
  - Works perfectly as the code intended

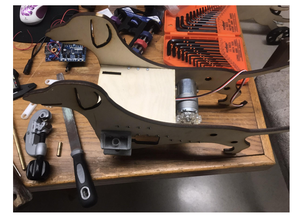


Fig 16. Snapshot of Build Progress (End of Week 8)

Future Improvements

- Make chassis larger, but still compact
  - More space to work with
  - Parts less likely to interfere with one another while in motion
- Reduce friction
  - There's a difference between CAD parts and manufactured parts
    - Need to get used to the nuances of fabricating (GD&T, Engineering Fit)

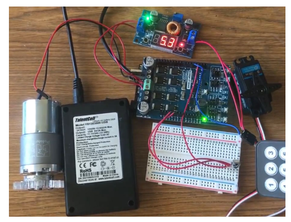


Fig 17. Snapshot of Electronics Test

References

1. McCarthy, J Michael, and Kevin Chen. *Design of Mechanical Walking Robots*. MDA Press, 2021.

Acknowledgements

Thank you to Professor McCarthy for advising us and mentoring us. Thank you to Ken Nguyen and Kevin Chen for helping us throughout the project. This would not have been possible without you all.