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PHYS265

Pymunk Crash Simulation: Evaluating Crash Dynamics

1. In this project, I use PyMunk, a physics engine, to simulate collisions and test how crumple zones affect safety of passengers.

2. The PyMunk package is a 2D physics simulation library, which is also built on top of the Chipmunk physics engine, allowing realistic simulation of collisions, rigid-body dynamics, and interactions. I used it to compare peak impulse experienced by the car with and without a crumple zone.

3. I chose PyMunk due to its ease of integration with Python and to easily visualize automotive crash dynamics. I wanted to see how real physics concepts can be visualized using python.

4. PyMunk was first introduced in 2007, and is based on the earlier Chipmunk2D physics engine. Some other engines are PyGame and Box2D, which are alternatives to PyMunk. Version used: PyMunk v6.11.1

5. PyMunk is actively maintained by its original author, Victor Blomqvist. It is also open source, alongside a community of contributors. The GitHub repository clearly outlines guidelines for contributing.

6. The installation was straightforward and completed without complications, using “pip install pymunk”

7. The installation is easy with no additional installations.

8. PyMunk source code is fully available for inspection at its GitHub repository at https://github.com/viblo/pymunk.

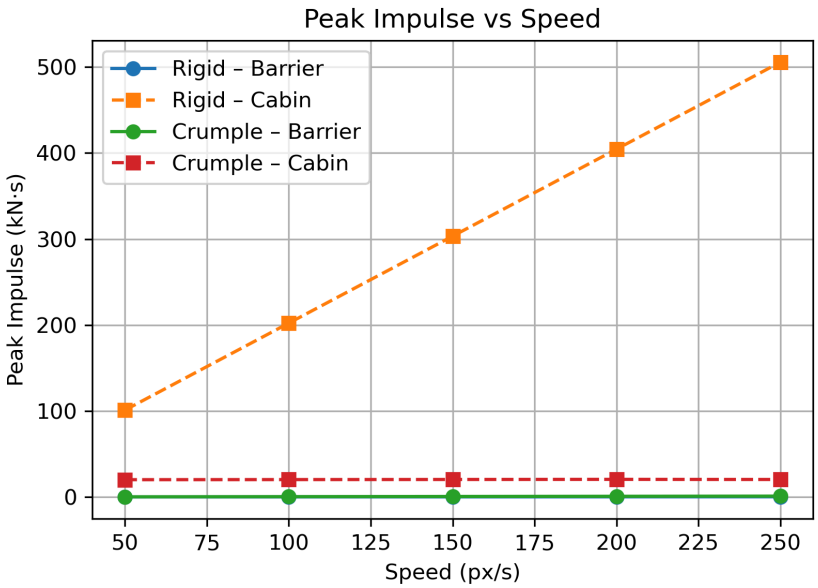
9. PyMunk is widely used in game development and educational simulations, for example in arcade games that use Pyglet alongside Pymunk, which is shared throughout the PyMunk community.

10. I used the package in Jupyter notebooks, which I used for testing and visualization

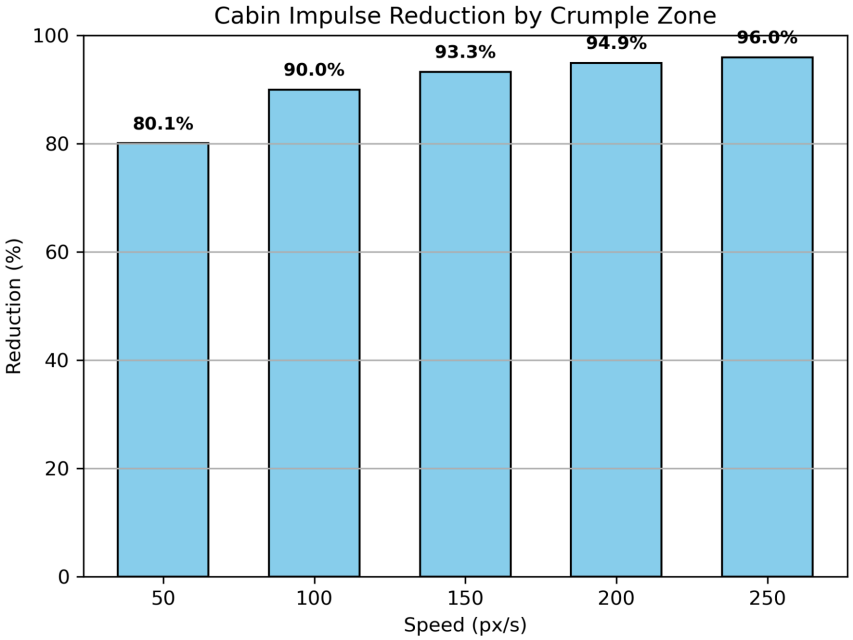
11. I wrote a function which creates two cars, one with a rigid body and other with a spring crumple zone. Example code and analysis were provided in a Jupyter notebook.

12. I used matplotlib to plot the graphs, since PyMunk itself does not produce figures directly.

13. This shows the peak impulse on the cabin for both the rigid and crumple designs. At all speeds, the crumple zone can significantly reduce cabin impulse, which is crucial for the safety of the passengers inside the vehicle, the higher the impulse, the more deadly the crash can be.



The bar chart shows the % of reduction in cabin impulse of crumple zone design compared to rigid design at different speeds.



14. It uses mostly python, which is also internally dependent on the Chipmunk2D C library, however, I would not see or use this.

15. The primary inputs to PyMunk are simulation variables such as speed, mass, spring stiffness, damping mass.

16. Output consists primarily of numerical simulation results, collision impulses, and I store in a data frame, visualizing using plots.

17. PyMunk provides a suite of basic tests to verify collision handling and physics calculations. I used runtime validation, plotting, etc.

18. The results are consistent, reproducible, and physically possible. The crumple zones output data expected from real crash physics.

19. The main packages used are Pymunk itself, matplotlib, and pandas.

20. Full documents are available through PyMunk's official website and GitHub repository, providing clear examples. It includes API references, guides, and tutorials.

21. PyMunk recommends citing its original GitHub repository and the Chipmunk2D physics engine.

22.

PyMunk GitHub repository: https://github.com/viblo/pymunk

Chipmunk2D: https://chipmunk-physics.net/

23.

Renna, Luca. "Deep Reinforcement Learning for 2D Physics-Based Object Manipulation in Clutter." *arXiv*preprint arXiv:2312.04570, 14 Nov. 2023.

Ran Ren, Hang Li, Tianfang Han, Chi Tian, Cong Zhang, Jiansong Zhang, Robert W. Proctor, Yunfeng Chen, Yiheng Feng, Vehicle crash simulations for safety: Introduction of connected and automated vehicles on the roadways, Accident Analysis & Prevention, Volume 186, 2023, 107021, ISSN 0001-4575, https://doi.org/10.1016/j.aap.2023.107021.

24. I had to learn the handling of DampedSpring joints and collision event callbacks within PyMunk, which had plenty of tutorials and examples.

25. This project was my first extensive use of PyMunk, and I have no prior experience with this specific package or similar package like PyGame or Chipmunk2D.