The red, blue, and yellow lines in your plots are the **trajectory of the neck keypoint's (X, Y) position over a window of 150 frames (5 seconds)**. We use the neck because, as you noted, it's a stable proxy for the person's overall path and less noisy than limbs. The model itself uses the orientation angles of *all* joints as input, but for visualization, the neck's path is the clearest way to see the person's movement.

The "Dense" Trajectory (Shoplifter Class)

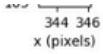
- **What it is:** A thick, scribbled line where the path traces over itself repeatedly. The start and end points are often close.
- **What it means:** This signifies **non-progressive, stationary movement**. The person is loitering in one spot, turning their head and upper body back and forth, or repeatedly interacting with a very small area.
- **Why it's suspicious:** This is a classic "shoplifter" signal. It's the visual pattern of someone casing an area, looking for cameras, or shielding their actions. the model correctly learns to associate this dense pattern with a high probability of shoplifting.

The "Simple" Trajectory (Normal Class)

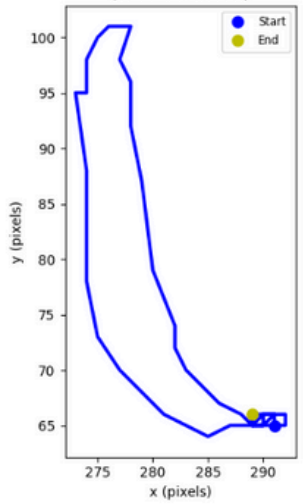
- **What it is:** A clean, single line moving from one point to another.
- **What it means:** This signifies **progressive movement**. The person is simply walking from A to B.
- **Why it's normal:** This is the most common pattern for a normal shopper moving through the store. the model correctly learns to associate this with normal behavior.

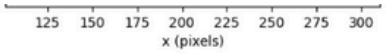
The "Complex / Jagged" Trajectory (Both Classes)

- **What it is:** A path with sharp turns, loops, and jagged edges, but it's not dense. The person covers a small area but doesn't trace the exact same path repeatedly.
- **What it means:** This signifies **localized interaction**. The person has stopped their "progressive" walk to interact with a product on a shelf. This can include bending down, reaching, putting a hand in a pocket, or placing an item in a cart.
- **Why it's confusing:** This is the most ambiguous pattern and is likely the source of many errors. A normal shopper picking up a can of soup creates a complex trajectory. A shoplifter concealing an item creates a *different*, but still complex, trajectory. The model's biggest challenge is learning to distinguish between these two types of complex patterns.



cam02_3m_picking_up_object_2023_2_16_17_22_17_002.csv
(Frames 2787-2937)





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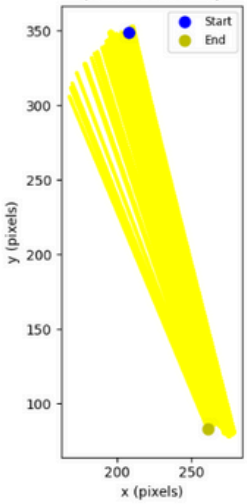
(Frames 5977-6127)

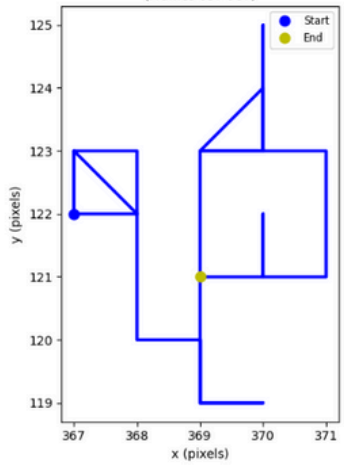


cam03_3m_picking_up_object_2023_2_16_17_22_17_002.csv

cam04_3m_state_looking_right_left-hide_object_2023_2_16_17_59_14_005.csv

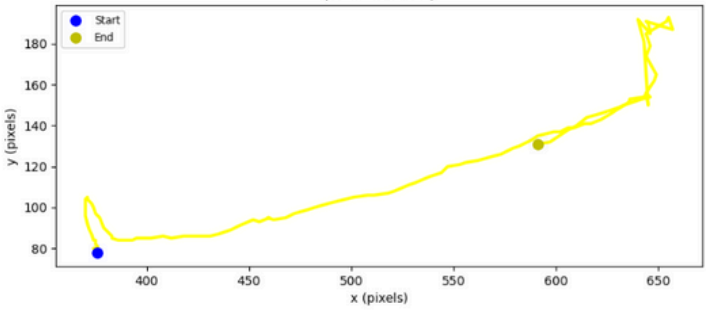
x (pixels)

cam06_4m_state_put_hand_in_pocket_2023_2_16_18_46_39_000.csv
(Frames 837-987)



cam08_5m_picking_up_object_2023_2_16_17_22_17_000.csv
(Frames 759-909)

cam04_3m_state_looking_right_left-hide_object_2023_2_16_17_59_14_000.csv
(Frames 645-795)



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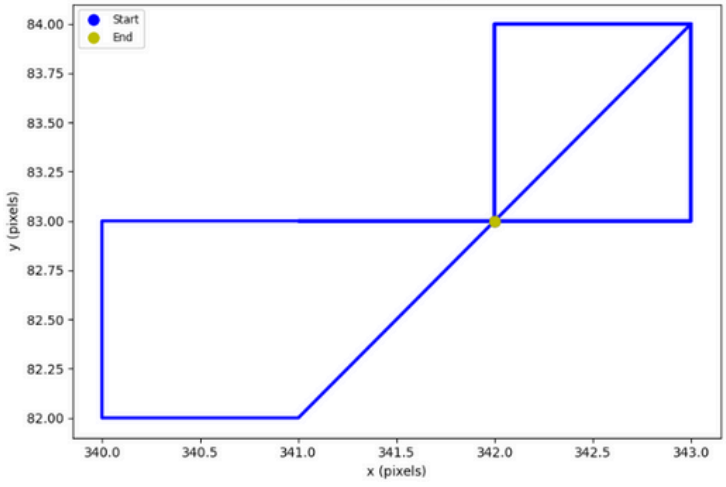
(Frames 26-176)



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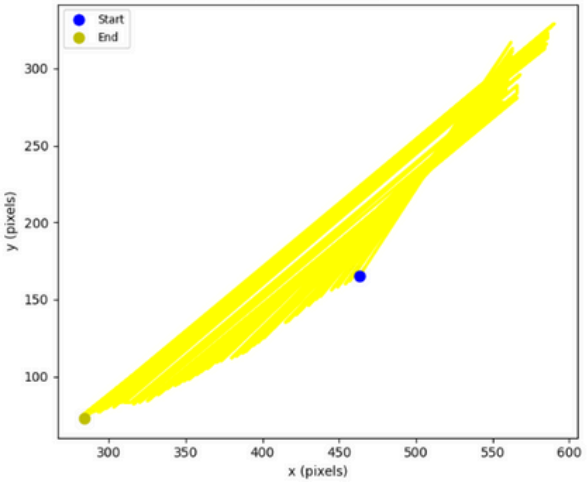
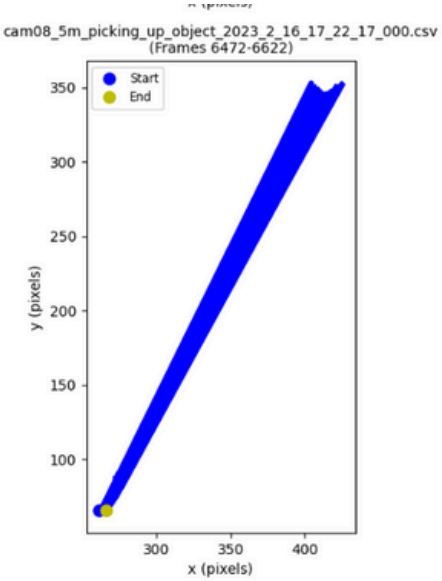
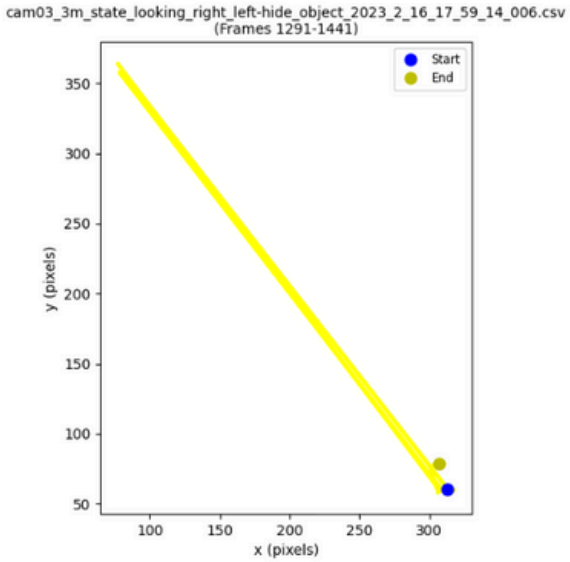
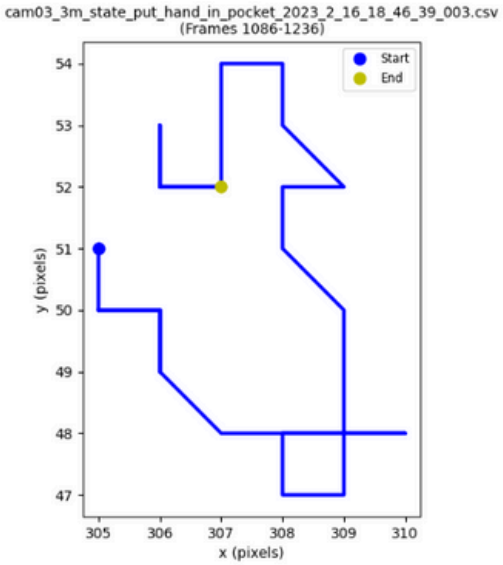
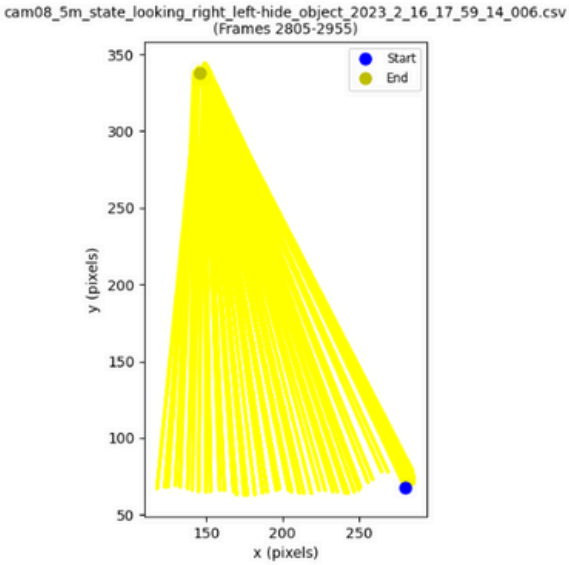
(Frames 4945-5095)





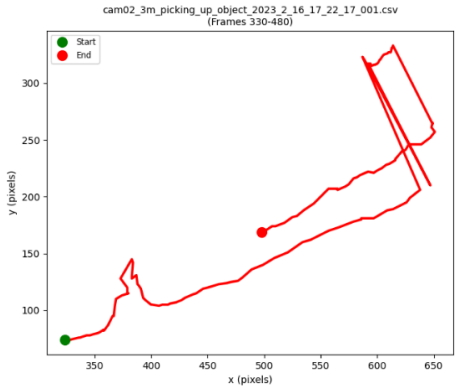


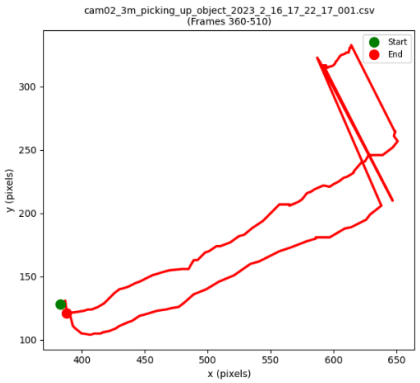


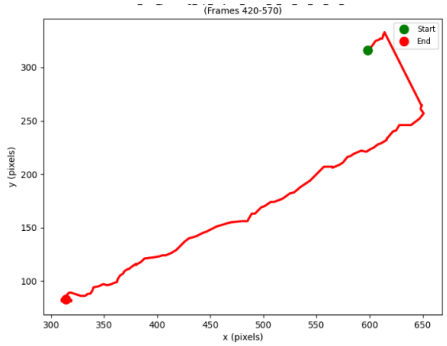


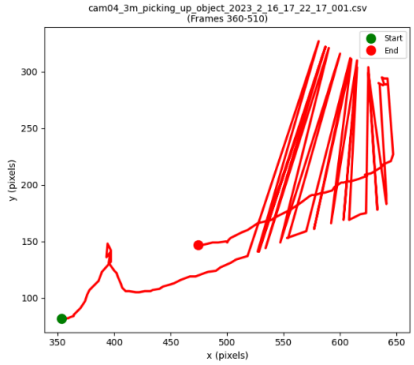
now models analysis on these same 2 videos it really shows

normal class:



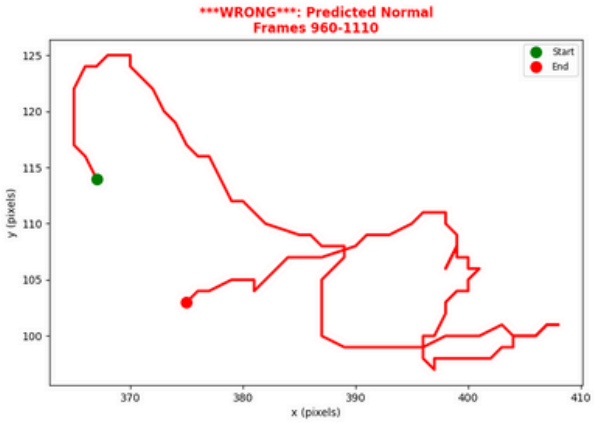


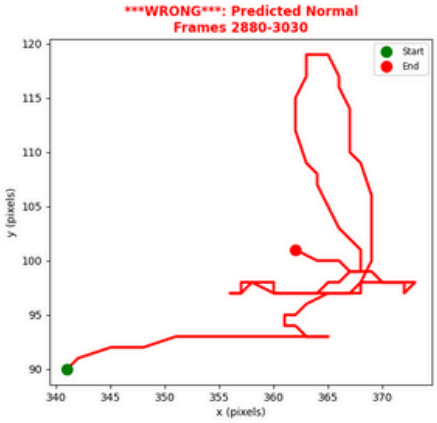


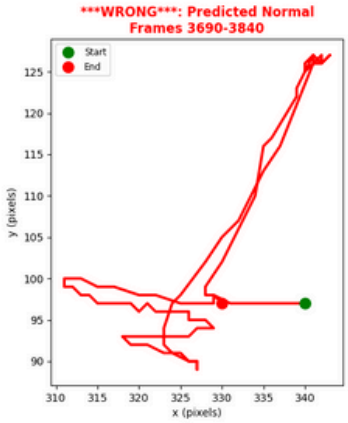


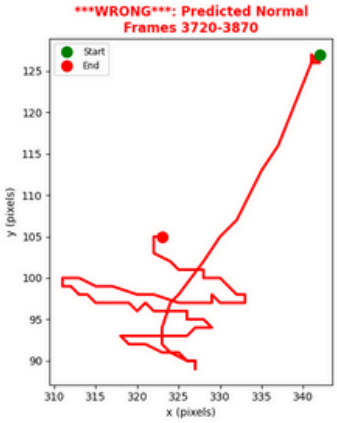
shoplifter class:

Model Failure Analysis









conclusion:

- normal class : which involves small, localized movements, the overall trend is **progressive**. They move along a path, stop, interact, and then *continue along the path*

- shoplifter class: The pattern is **non-progressive**
- **Why the model failed:** In those specific 2.5-second windows, the shoplifter was simply walking from one point of interest to another. Their trajectory, ***when viewed in isolation***, looked identical to a normal person's. The model was shown a pattern that perfectly matched its definition of "Normal" and made a logical, but ultimately incorrect, prediction.

I believe it’s a problem with how we test the model in isolation where we give it a window and tell it is this shoplifting activity or not

but with the testing approach I’ve proposed where we do more of a probability this fault could be avoided Instead of asking "Is this single window suspicious?", we should be asking, "What is the probability this *person* is suspicious, based on the history of their last ***N* windows**?" This way, a single, brief moment of normal walking wouldn't exonerate a shoplifter, and a short, innocent pause wouldn't condemn a normal shopper. This holistic approach, which avoids the pitfalls of judgment in isolation, is the clear path forward to making this system robust and reliable

but the problem of the jagged lines and the similarities between someone picking up a product off the shelf and someone stealing still remains but this approach at least is more lenient to the normal class as it makes the model have memory and try to be as sure as possible of the shoplifter before classifying it