# Particle Filter Visual Guide

Over the last several semesters the TAs have identified a number of common situations students encounter when working through the Solar System Particle Filter project. Some of these situations might be identified from the project's visualization of the first few time steps.

Although this guide was developed to aid students in tuning and diagnosing potential situations encountered while working on the Solar System Particle Filter project, it is not intended to identify every scenario, nor is it a guarantee that the visuals provided in this guide will accurately identify your situation.  This guide should be thought of as offering suggestions of functionality in your implementation that may be worth investigating.

As there are a number of important elements, such as the number of particles, particle placement, weighting, resampling, fuzzing and target location estimation, for constructing a fully function particle filter.  If more than one of these elements is off, you may find that the visual guide is less helpful.

It is important to note that this is a guide based on visualizations. There are a number of possible conditions that can create similar visuals, which could result in a misleading diagnosis. It is possible some solutions, although not fully tuned, could eventually reach the desired objective given enough time steps.

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A GOOD WORKING SOLUTION: After the first resample, Figure 1 shows that weighting is working as rings form around the planets where the gravimetric measurements are similar to that of the satellite's measurements. Also, there are particles on/near the target. Figure 2 shows successful clustering around the target indicating weighting, resampling and fuzzing appear to be working. Notice that it is only time step 3 and clustering around the target has occurred very quickly. The small cluster of particles in the left upper quadrant will soon disappear as they will tend to not be selected in the resampling process.
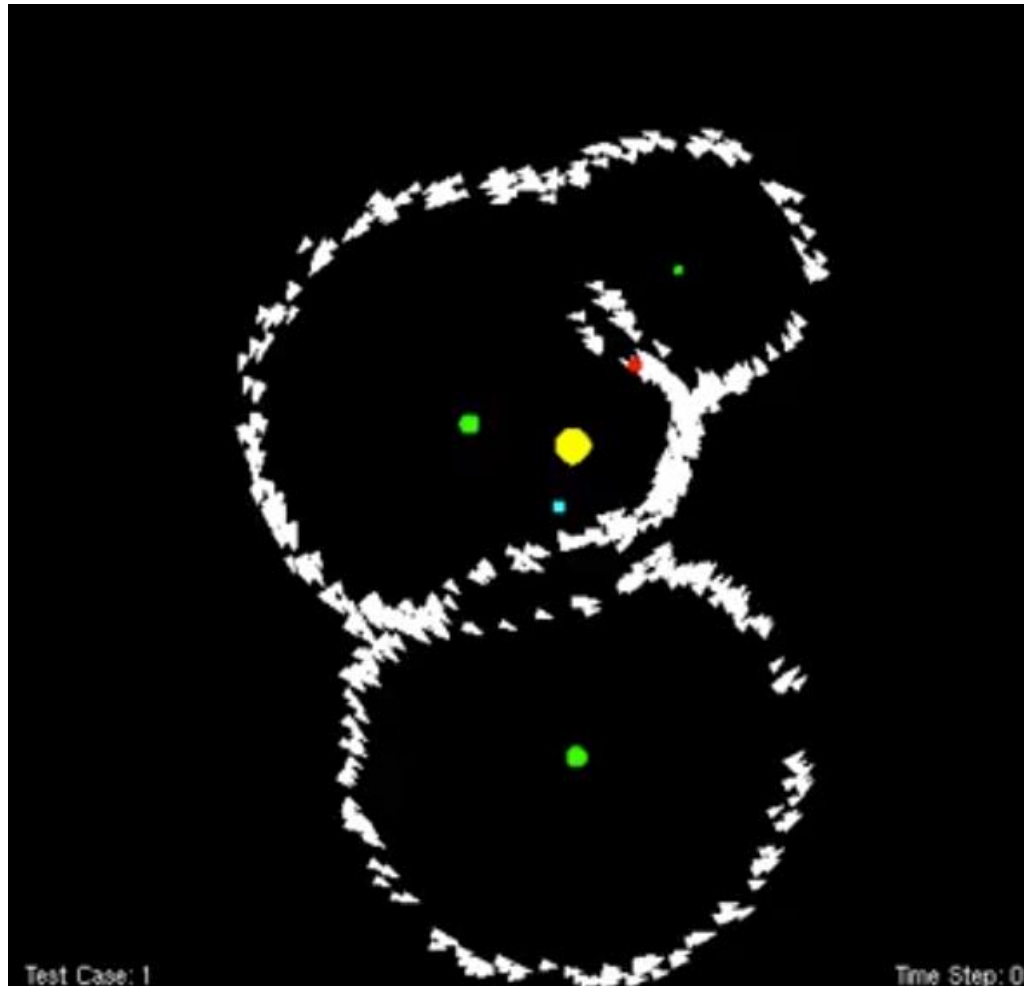


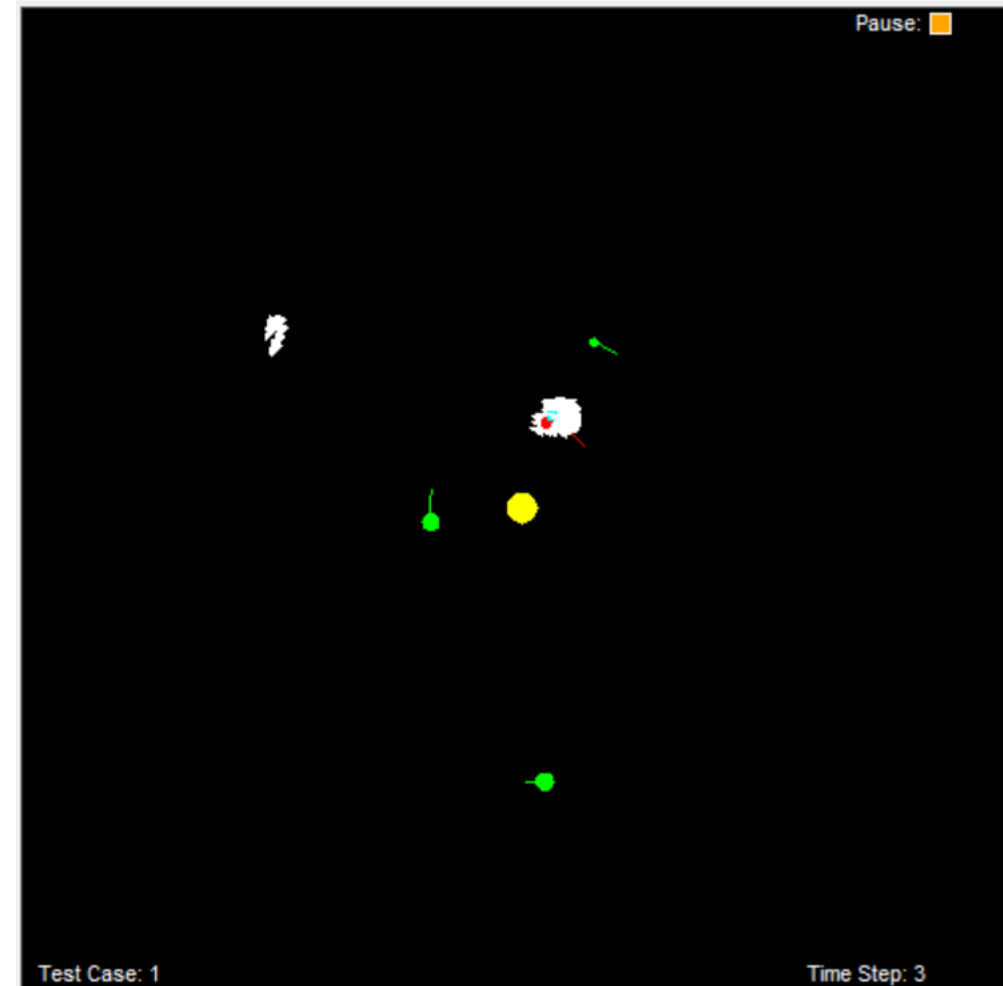Figure 1 – Initial time steps showing positive results

Figure 2 – A few steps in show positive target clustering

SMALL SIGMA OR LOW PARTICLE COUNT: After the first resample, Figure 3 shows that there is clustering of the particles, but not near the target satellite. This could indicate there are too few particles to cover the given area or that the sigma value used is too small. Figure 4 shows particles are disappearing in just a couple of time steps as the gravimetric measurements are not able to be matched. Without particles on/near the target, it is unlikely for this situation to improve and locate the satellite.
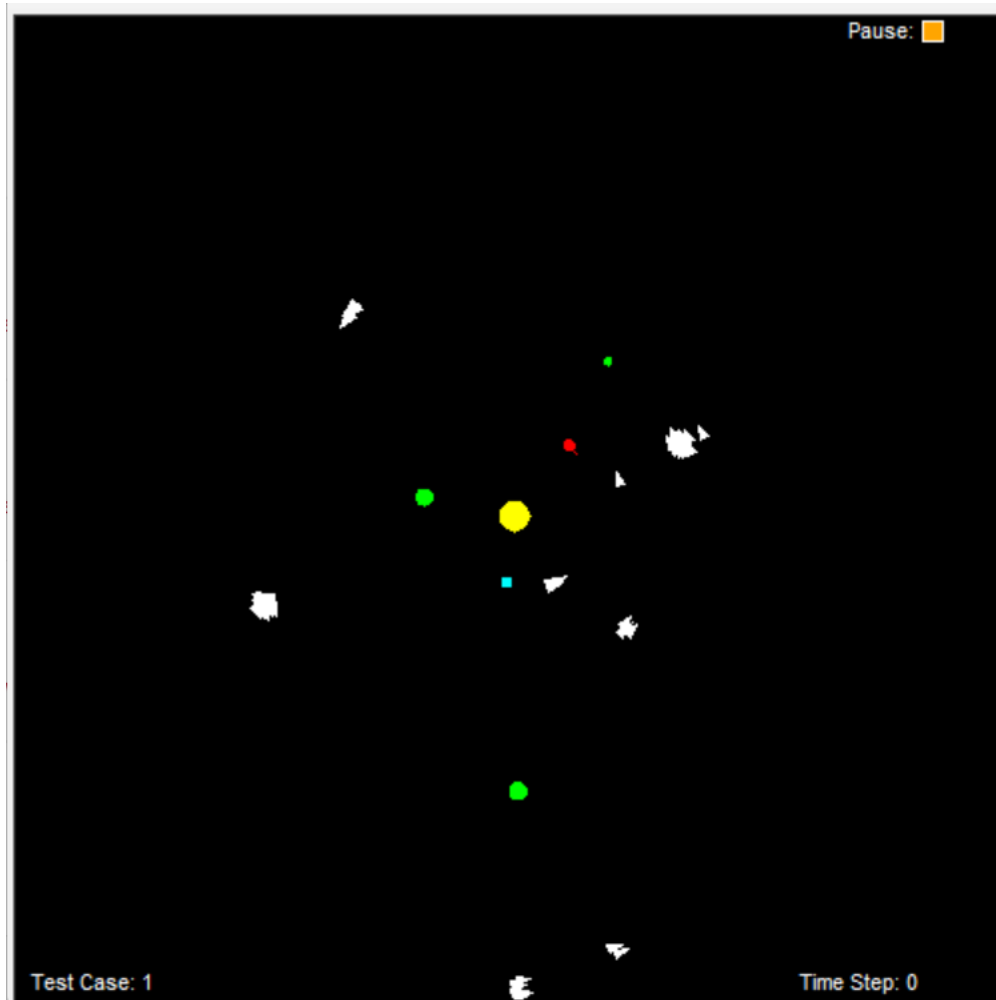


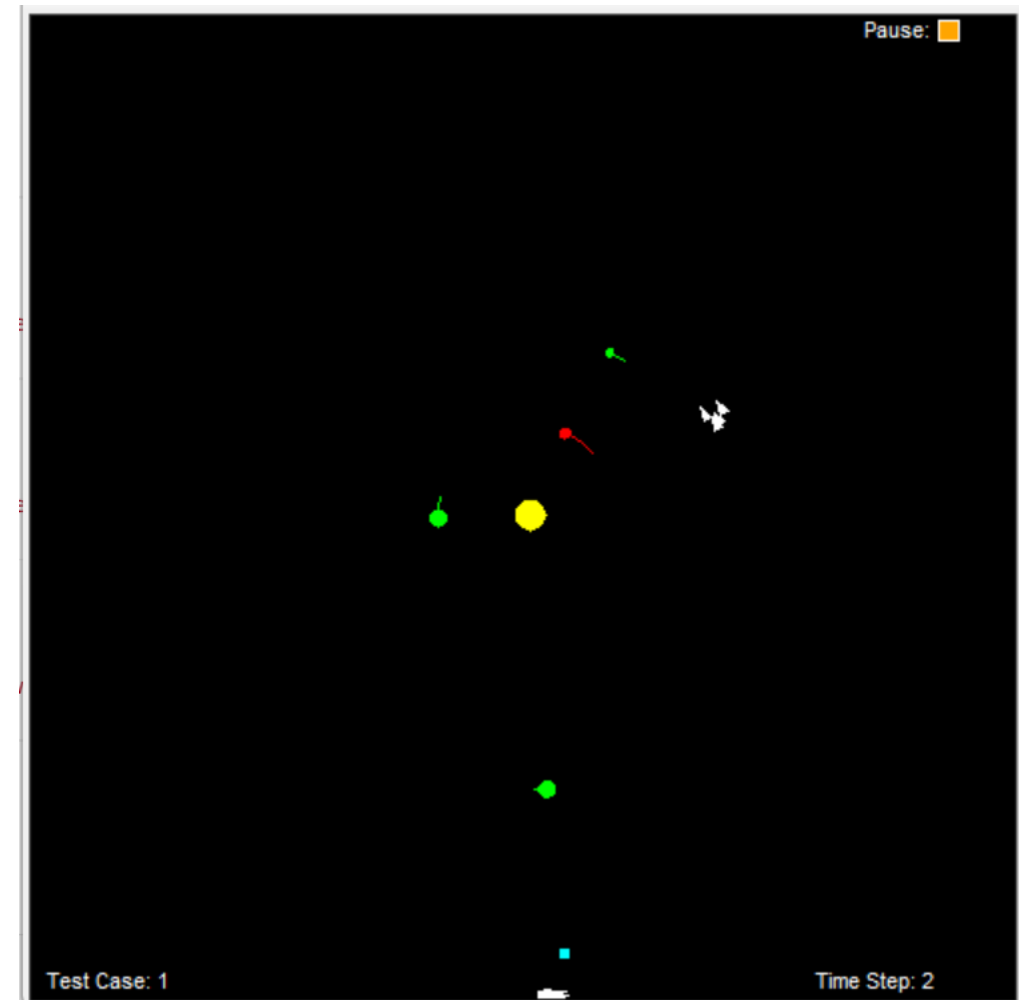Figure 3 – Initial time steps showing too few particles

Figure 4 – A few steps in show disappearing particles

POSSIBLE INSUFFICIENT FUZZING: After the first resample, Figure 5 shows that weighting is working as rings around the planets form where the gravimetric measurements are similar to that of the satellite's readings. Figure 6 shows the number of varied particles is reducing after only one time step. This is a possible sign of insufficient fuzzing, which will reduce the possibility of finding the target especially if particles are not on or very near the target.
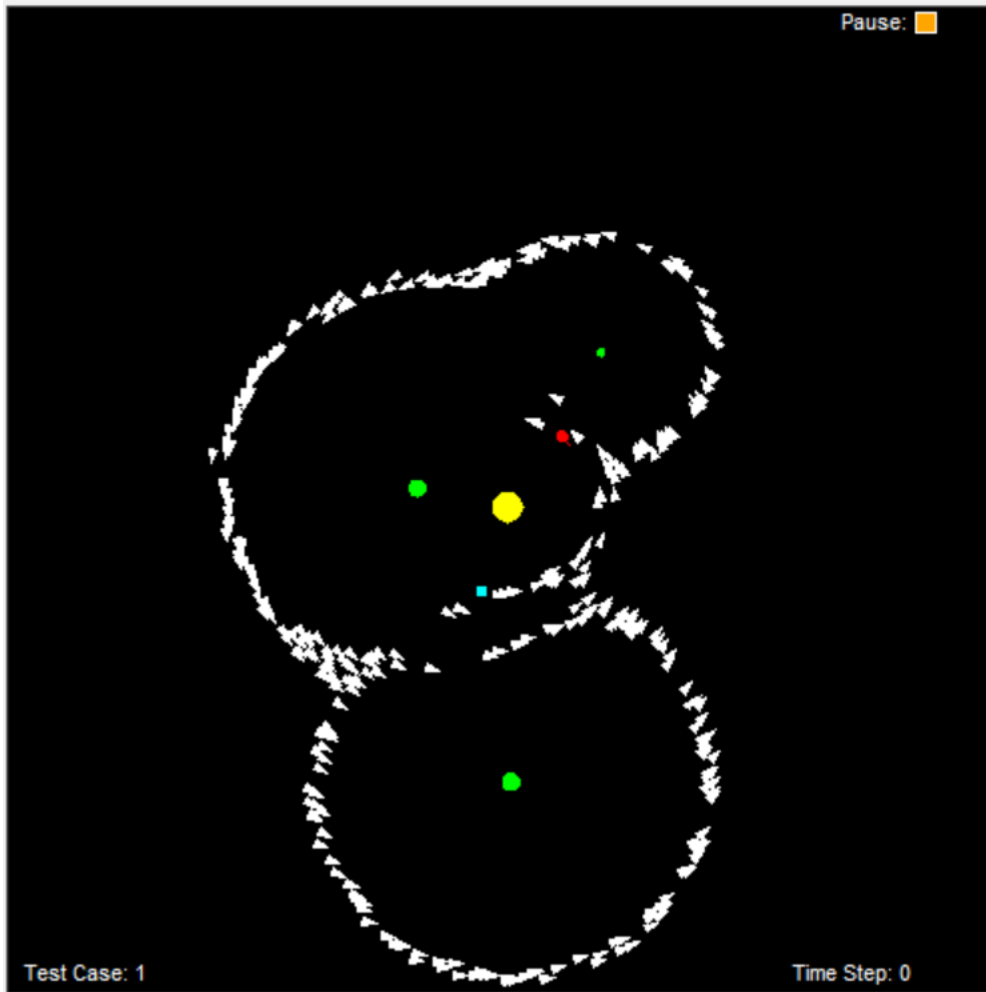


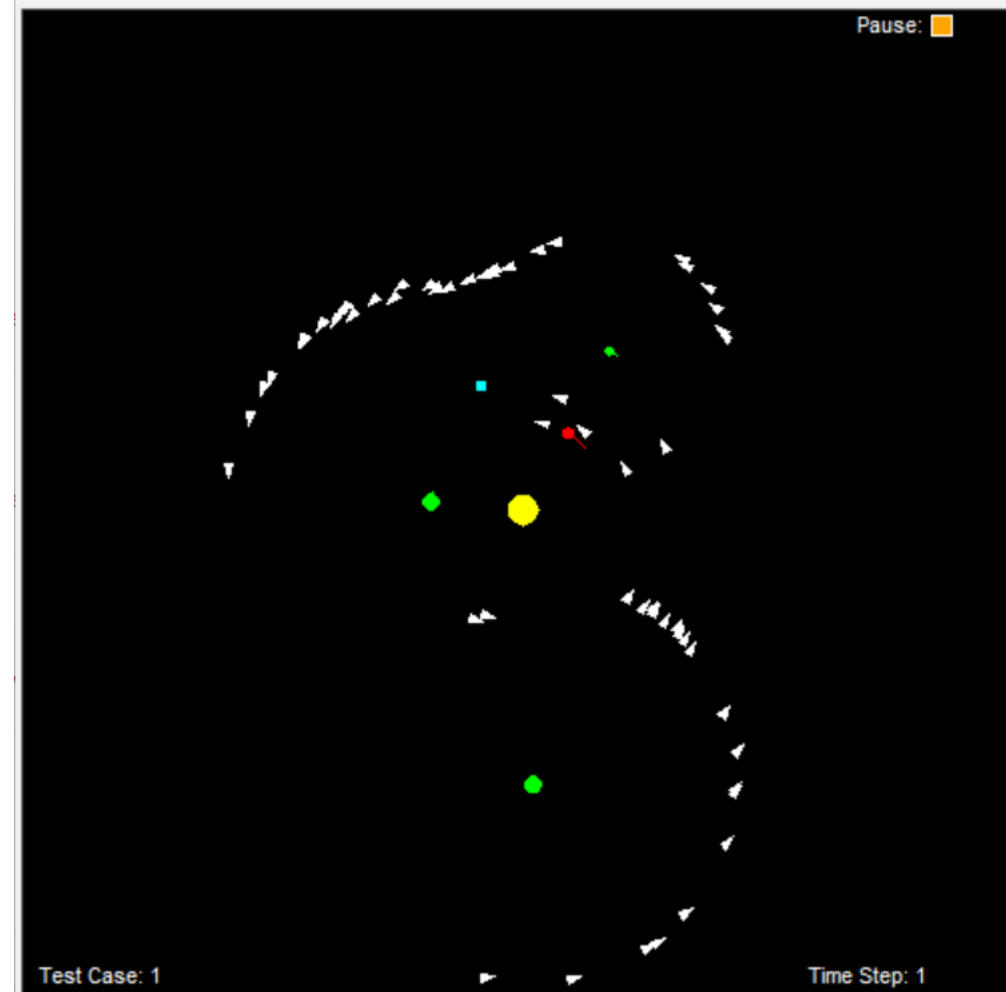Figure 5 – Initial time steps showing positive results

Figure 6 – A few steps in show loss of clustering & particles

WEIGHTING MAY BE INCORRECT/SIGMA VAULE TOO HIGH: After the first resample, Figure 7 shows that weighting may not be working correctly. If cluster rings do not form within a few time steps, check the weighting calculations. If the sigma value is too high you may see a similar result. Figure 8 shows some signs of clustering, but no cluster rings or convergence on the target.
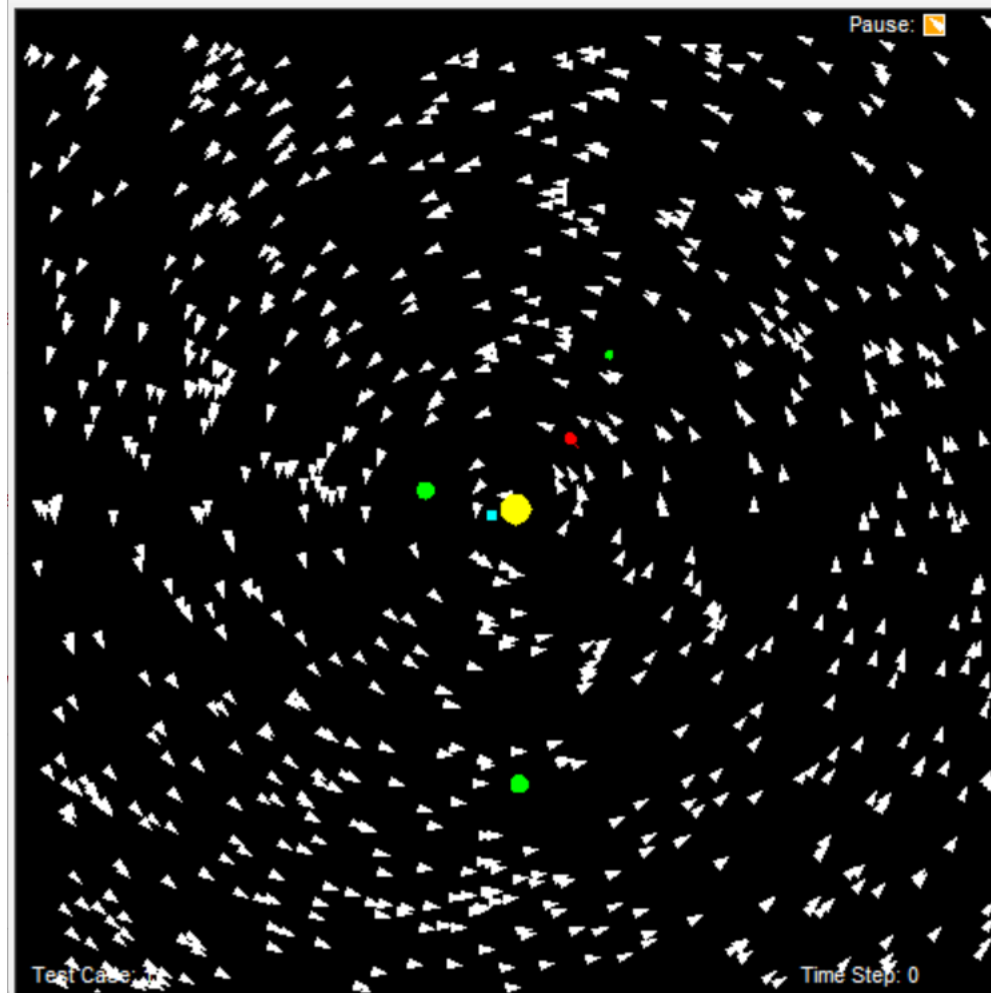


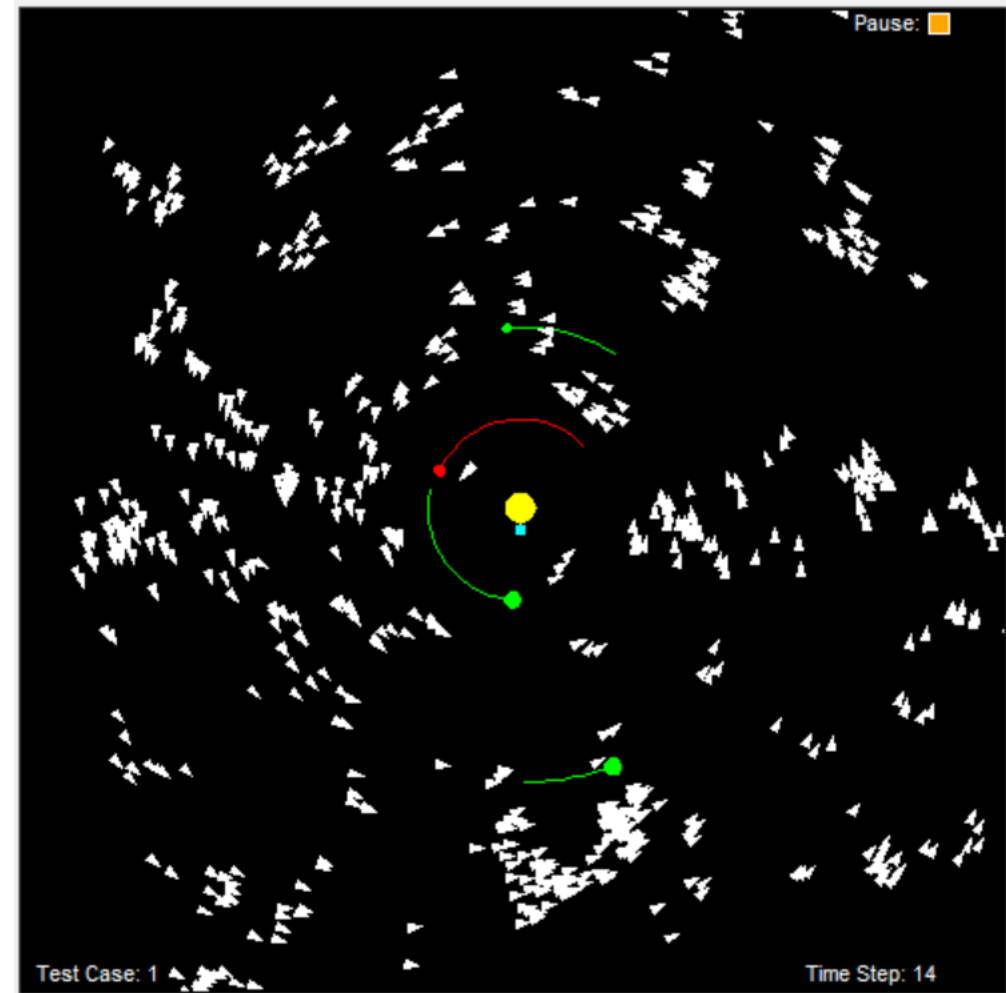Figure 7 – Initial time steps showing no clustering

Figure 8 – Several steps in show possible weighting issue

WEIGHTING MAY BE INCORRECT/SIGMA VAULE TOO LOW: After the first resample, Figure 9 shows that weighting may not be working correctly. These splotchy clusters or even a single cluster at this early time step could be a sign of a problem with the weighting calculation.  Check that the sigma value may be too low.  Figure 10 shows that the particles are all clustering in one area, but not where satellite is located.
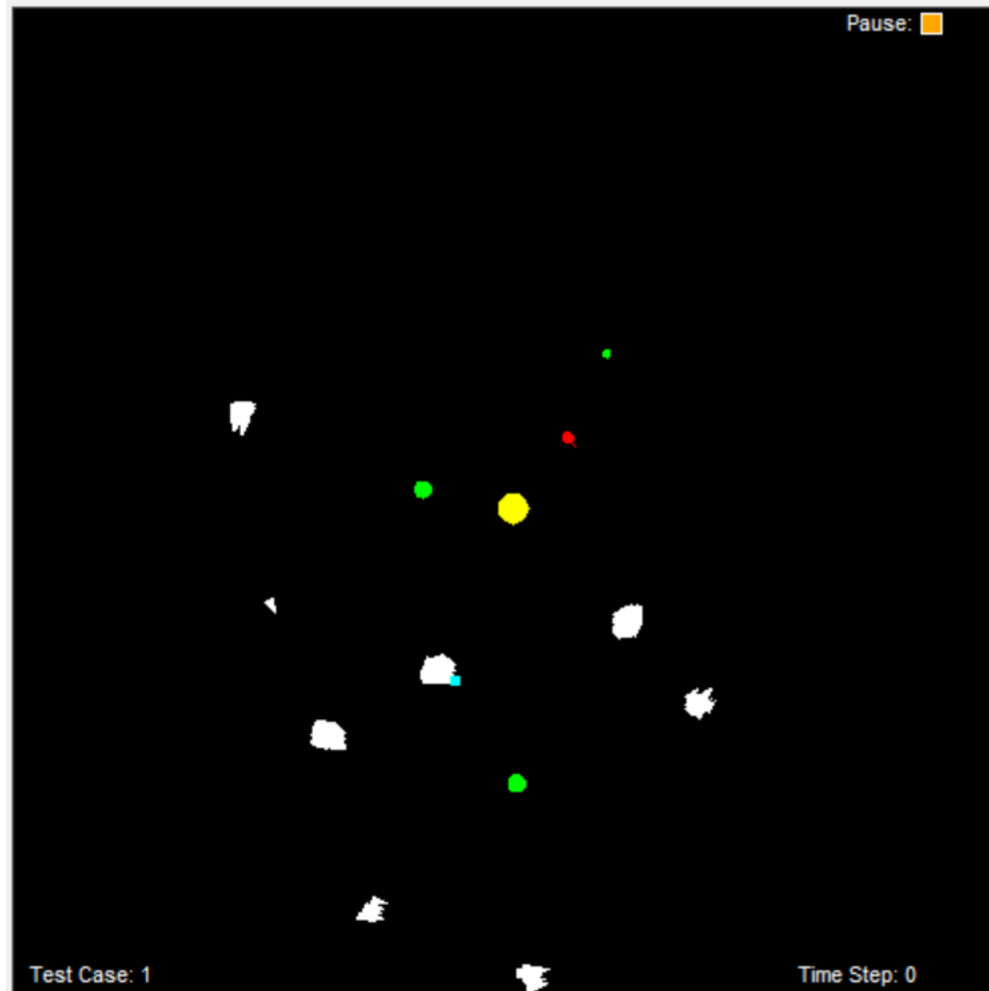


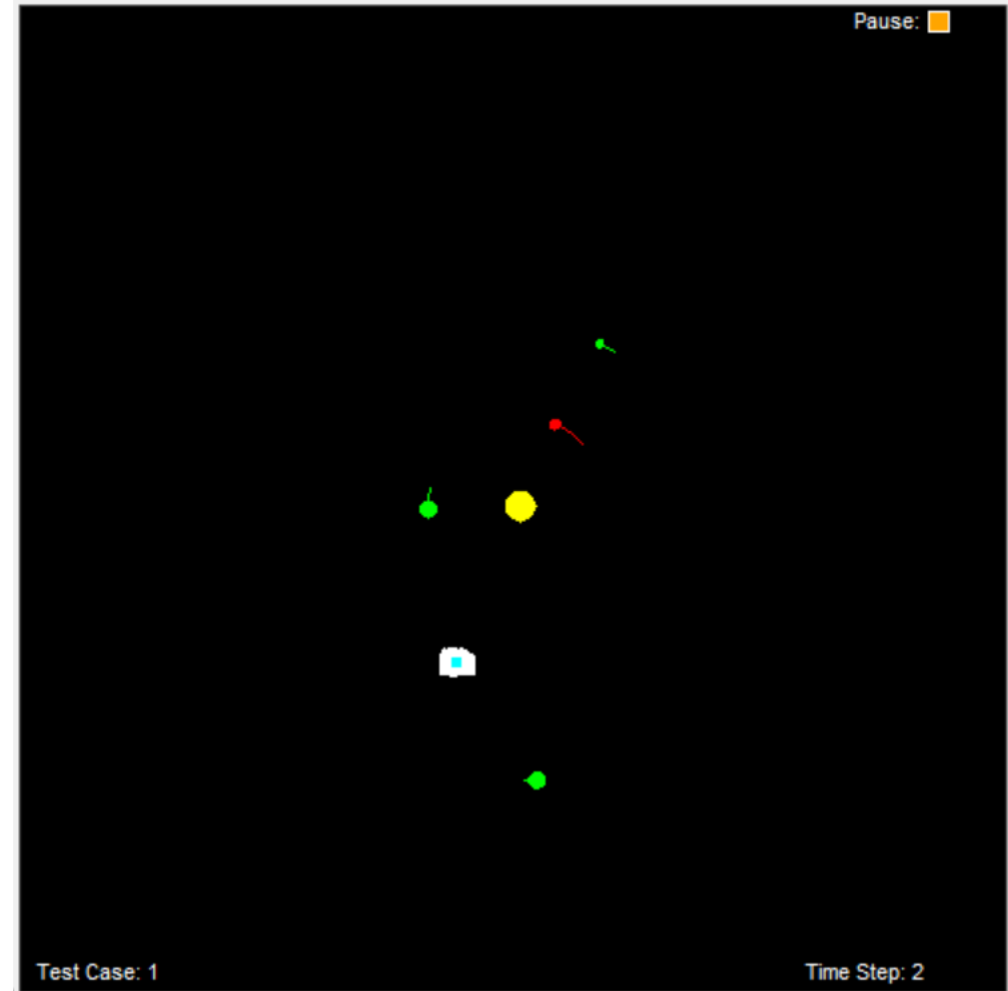Figure 9 – Initial time steps showing a few dense clusters

Figure 10 – All particles clustering in one non target location

WEIGHTING WITH SIGMA VARIATIONS (SLIGHTLY HIGH / SLIGHTLY LOW/ JUST RIGHT): After the first resample, Figure 11 shows a more disbursed set of particles formed around the planets. This is an indication that the sigma used in the weighting process is slightly too large. Figure 12 shows a clumpy particle formation around the planets. This is a sign that the sigma used in the weighting process is a little too small. Figure 11 shows that weighting is working correctly as rings form around the planets where the gravimetric measurements are similar to that of the satellite's readings.
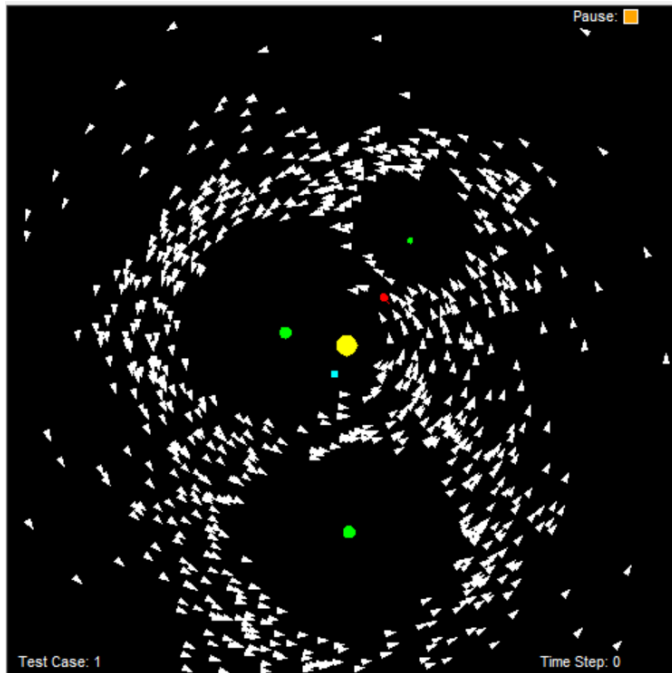


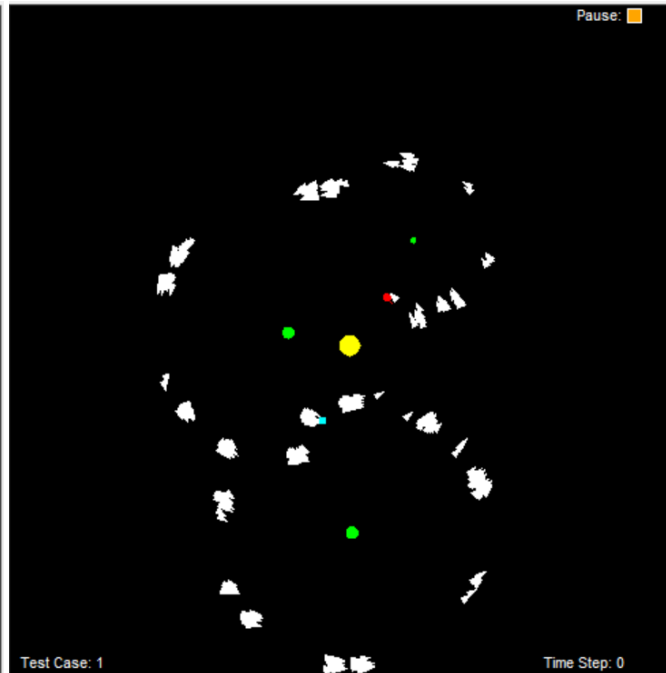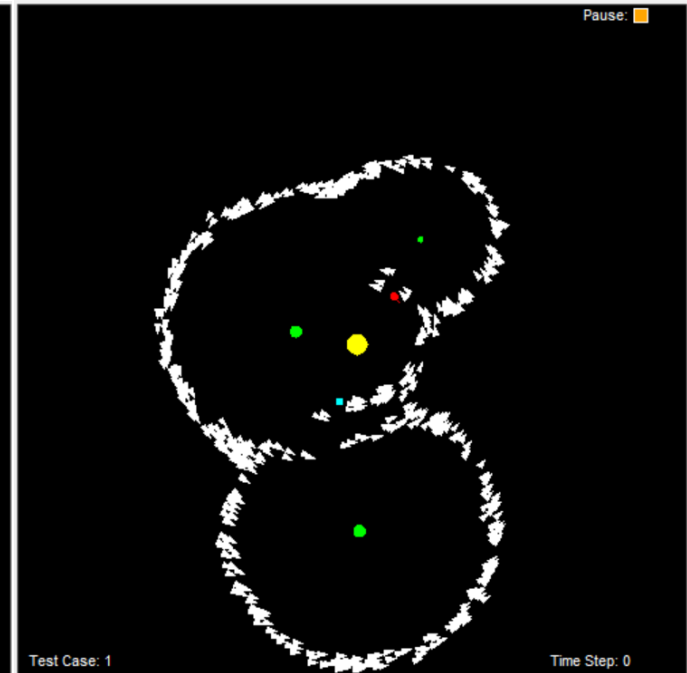Figure 11 – Weighting sigma is a little large     Figure 12 – Weighting sigma is a little small          Figure 13 – Weighting is working