1. **Date of this final project report submission**

12/24/25.

2. **Name of project exactly as it was listed in your award letter**

Automated Waste Classification via Computer Vision.

3. **Date (or semester/year) of original award letter**

12/04/2023.

4. **Expiration date of award as listed on original award letter or approved scope change letter - whichever is more recent**

12/03/2025.

5. **Enter the amount of the award, including any budget increases as a result of a previous scope change.**

$96600.

6. **What is your project's 6 digit fund account number created for this project and to which the SSC allocation was transferred? Please ask your project's financial contact for this information if unknown.**

1-304790-251000-251486.

7. **How much (in dollars) of your award (including previous approved budget increases) is remaining?**

$0.

8. **Briefly describe the goals of your project.**

The goal of the project was to generate a diverse and representative dataset of recyclable materials from the campus waste stream and then use this dataset to develop an automated system for waste classification. The project aimed to create a computer-vision model capable of detecting and identifying common recyclable items on the conveyor belt and to implement a counting tool that could track material inflow and outflow in real time. By producing consistent classification and counting data, the project sought to provide a clearer understanding of campus waste patterns and lay the groundwork for future automation efforts.

9. **Did you complete your project as it was outlined in the original award letter or in a subsequent approved scope change?**

Yes, the project was completed as outlined in the original award letter. The main objectives to collect video data, generate a diverse dataset of recyclable materials, and

develop an initial computer-vision system for automated waste classification were achieved. The project also included an additional component, real-time weight measurement, which was not part of the original plan but was added to improve the system's ability to quantify material flow. This addition supported the overall goals without changing the approved scope of work.

10. **On what date did you consider the project finished or that you stopped working on it?**

12/1/2025.

11. **Describe, in detail, the challenges / obstacles your project faced.**

During the project, several challenges were encountered. The first major obstacle was object occlusion. Many recyclables appeared in clusters, were partially covered, which made annotation difficult and required extensive manual correction to maintain dataset quality. A second challenge was the appearance of unfamiliar items on the conveyor belt that were not well represented in the initial dataset. As a result, the model often misclassified these items or failed to detect them altogether. Addressing this issue required additional rounds of annotation through active learning, including using the initial model to pre-label frames that were then manually reviewed and corrected.

Finally, the last challenge involved setting up the camera system itself. Installing and aligning the cameras above the conveyor belt required careful coordination to ensure the full width of the belt was visible, minimize interference from surrounding equipment, and maintain consistent lighting throughout the day. The installation and calibration of weight sensors also presented hardware-related difficulties, including ensuring consistent readings and aligning weight measurements with video timestamps. In addition, retrieving weight data remotely remains an unresolved challenge, as a reliable wireless or network-based data transfer method has not yet been implemented.

12. **Describe, in detail, the successes your project experienced.**

The project achieved several important successes that collectively demonstrate the feasibility and value of an automated waste-classification system at the Waste Transfer Station (WTS). One of the most significant accomplishments was the creation of the first comprehensive, campus-specific dataset of recyclable materials captured directly from the conveyor belt. By collecting continuous RTSP (Real-Time Streaming Protocol) video, a method for streaming live video, from both ends of the sorting line and annotating approximately two thousand frames using polygon-based segmentation, in which object boundaries are manually outlined to capture precise shapes and overlapping items, the project produced a high-fidelity dataset that accurately represents real operating conditions, including overlapping items. This dataset did not previously exist and now

serves as a foundational resource for future AI and robotics work on campus waste systems.

A second major success was the development and training of an initial AI model capable of detecting and classifying several key recyclable materials in real time. The model demonstrated strong performance on common items such as PET bottles, HDPE containers, aluminum cans, cardboard, and paper. The use of active learning also improved model performance by identifying unfamiliar categories and allowing targeted dataset expansion. This represents the first functioning, campus-trained computer-vision model for waste classification at UIUC.

The project also successfully implemented a real-time tracking and counting system using YOLO (You Only Look Once), a single-stage object detection algorithm optimized for real-time inference, together with DeepSORT (Simple Online and Realtime Tracking with a Deep Association Metric), a multi-object tracking method that maintains object identities across frames using motion and appearance cues, and custom Python scripts. This system assigned unique IDs to detected items, tracked their movement across frames, and counted each object as it crossed a virtual line. The system was able to track materials entering and leaving the manual sorting area, providing an initial estimate of the diversion rate and demonstrating how computer vision can supplement manual observation.

Another important success was the installation and integration of a digital weight sensor along the conveyor belt. The sensors streamed continuous mass measurements that could be aligned with video timestamps, offering a second modality for quantifying material flow. Although weight measurement was not part of the original plan, its integration significantly strengthened the system by enabling cross-validation of detection counts and paving the way for future mass-flow estimation tools.

Lastly, the project showed that an automated monitoring system can function reliably in a real waste-sorting environment. Stable camera operation, consistent data collection, and dependable model performance confirmed that computer vision and weight-based measurement are practical tools for supporting campus sustainability efforts. These outcomes provide a strong technical foundation for future robotic sorting development and waste-stream analytics at the University of Illinois.

13. **Describe, in detail, how your implemented project addressed sustainability.**

The project advanced campus sustainability by creating an automated system that improves how recyclable materials are monitored. The computer-vision model provided consistent identification and counting of recyclables, offering clearer insight into diversion rates and supporting more effective recycling strategies. The development of a high-quality dataset and real-time tracking tools also built the foundation for future automated

sorting technologies, which can reduce contamination, increase recovery of recyclable materials, and lower landfill waste. The integration of weight sensors added quantitative data on material flow, enabling a more accurate assessment of how much recyclable material is actually recovered. Together, these contributions support the University's long-term sustainability goals by improving efficiency, reducing waste, and enabling data-driven decision-making.

14. **Describe, in detail, how your project integrated student involvement and community outreach.**

The project provided students with hands-on experience in AI and sustainability work. Students contributed to data collection, image annotation, model training, and system testing, gaining practical skills in computer vision and machine learning. They also led guided tours of the Waste Transfer Station for other students and visitors, helping explain campus waste operations and the role of automation in improving diversion efforts. In addition, students had opportunities to travel to conferences to engage with broader research communities. These experiences strengthened their technical abilities, communication skills, and overall understanding of real-world sustainability challenges.

15. **Describe how the project engaged individuals from underrepresented groups and/or how it promoted diversity, equity, and inclusion.**

The project promoted diversity, equity, and inclusion by making participation accessible to students with a wide range of academic interests and technical backgrounds. Tasks such as data annotation, model testing, field setup at the Waste Transfer Station, and coding support allowed students to contribute at different skill levels. This flexibility enabled more students to participate in AI and sustainability research, including those who may not have prior experience in computer vision. By creating a collaborative environment and offering multiple entry points into the project, the team helped expand opportunities for students to develop new skills and engage with campus sustainability efforts.

16. **What key takeaways should the campus community know about your project?**

The key takeaway from this project is that automated waste monitoring is both feasible and necessary for improving recycling performance at UIUC. By combining computer vision, continuous video monitoring, and weight measurements, the project demonstrated that it is possible to track the flow of recyclables in real time and generate reliable data that has never been captured before. This information can help the University better understand its waste stream, identify opportunities to increase diversion, and support future development of robotic sorting systems. The project also showed the importance

of student involvement, as students played a central role in data collection, AI model development, and outreach activities, helping advance campus sustainability goals.

17. **Describe the marketing material developed for promotion of your project, including but not limited to advertising (including digital) and/or signage related to this project. All marketing must include SSC's logo and/or a statement of which fee funded the project. Projects must coordinate with SSC to ensure the promotion appropriately highlights the SSC's contributions to the project.**

The marketing efforts will come into play once the model is ready to be integrated into a public-facing online interface.

18. **Upload project marketing and/or media not previously submitted in semester progress reports.**

A detailed PDF report is attached to this office form.

19. **Complete and upload the semester financial documentation for your project. You should reflect all expenditures since your last semester project report. We strongly suggest that you also upload supporting financial transaction reports from Banner for your award's CFOP. Talk to your project's financial advisor for more information on generating this report.**

See Attachments.