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Automated Ladle Tracking in Steel Production: Optimizing Efficiency and Data-Driven Decision Making

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ABSTRACT

Manual tracking of hot metal ladles, steel ladles, and slag pots in steel production poses challenges in accuracy, timeliness, and data availability. This paper proposes an automated tracking system using YOLOv8, a deep learning object detection model, to address these issues. By automatically identifying and tracking painted ladle numbers in real-time, the system provides accurate location information and enables data-driven process optimization. Benefits include improved tracking accuracy, real-time data for informed decision-making, calculation of ladle performance metrics, and potential for predictive maintenance. Evaluation results demonstrate the effectiveness of the proposed system, highlighting its potential to significantly improve efficiency and data-driven decision-making within steel production facilities.

1. INTRODUCTION

Efficient movement and management of vessels like hot metal ladles, steel ladles, and slag pots are crucial for smooth steel production. However, relying solely on manual tracking methods presents significant drawbacks in accuracy, timeliness, and data availability. Inaccuracies in manual tracking can lead to process inefficiencies, delayed decisions, and missed opportunities for optimization. Additionally, manual data collection is time-consuming and lacks real-time updates, hindering informed decision-making based on current ladle statuses. International Journal for Modern Trends in Science and Technology

In steel production, traditional **manual tracking** of hot metal ladles, steel ladles, and slag pots relies heavily on human observation and record-keeping. Workers visually identify ladles by painted numbers, manually log their locations and movements at designated checkpoints, and update spreadsheets or databases with this information. While seemingly straightforward, this approach suffers from

Drawbacks and limitations of manual tracking:

- **Accuracy:** Human error is inevitable, leading to misidentified ladles, misread numbers, and incomplete data entry. These inaccuracies can disrupt production flow, impact material traceability, and skew performance analysis.

- **Timeliness:** Manual tracking is inherently slow and time-consuming. Waiting for updates, verifying entries, and compiling reports create delays, hindering real-time decision-making and response to changing production needs.
- **Data Availability:** Information is often siloed in paper forms or spreadsheets, limiting real-time data access and analysis. This restricts process optimization, historical trend analysis, and proactive maintenance strategies.
- **Process Optimization:** Without real-time location data, optimizing ladle flow, minimizing wait times, and adjusting processes based on ladle status becomes challenging. Missed opportunities for efficiency improvements can lead to production bottlenecks and increased costs.
- **Performance Analysis:** Calculating key ladle metrics like circulation times, life cycle analysis, and turnaround times relies on accurate and timely data. Manual tracking often lacks this granularity, hindering informed decisions on ladle maintenance, replacement strategies, and overall performance evaluation.

Therefore, while manual tracking may seem like a simple solution, its inherent limitations in accuracy, timeliness, data availability, and its impact on process optimization and performance analysis make it increasingly unsustainable in modern, competitive steel production environments. To address these challenges and enable data-driven process control, an **automated tracking system** utilizing the power of **YOLOv8**, a state-of-the-art deep learning object detection model. This system automates the identification and real-time location tracking of ladles.

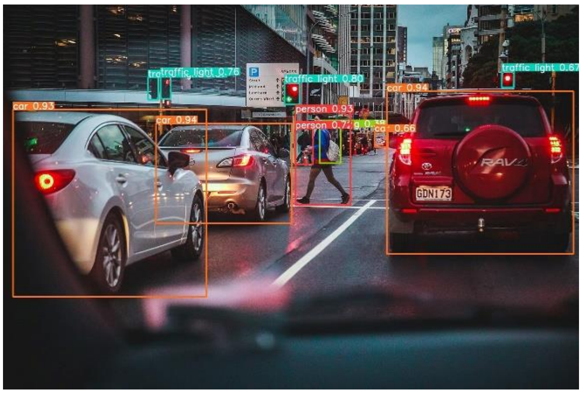
A. YOLOv8 Auto Tracking System:

Stepping away from the limitations of manual tracking, the YOLOv8 auto tracking system offers a transformative approach to ladle identification and location monitoring in steel production. Leveraging the power of deep learning and object detection capabilities of YOLOv8, this system overcomes the drawbacks associated with manual methods, paving the way for improved efficiency, data-driven decision making, and optimized ladle management.

Imagine a bustling steel production facility, where hot metal ladles, steel ladles, and slag pots weave between stations in a complex dance. Traditionally, human eyes and handwritten logs tracked their movements, prone to fatigue, errors, and delays. Enter YOLOv8, a powerful deep learning model, poised to revolutionize this tracking system.

The YOLOv8 automated tracking system acts as a tireless observer, equipped with strategically placed cameras. These cameras capture real-time footage, feeding it to YOLOv8, trained on a dataset of labeled ladle images. With lightning speed and impressive accuracy, YOLOv8 detects and tracks each ladle based on its unique painted number, eliminating human error and misidentification.

But YOLOv8 doesn't simply identify; it tracks. Data on each ladle's location and movement flows seamlessly to a central server, accessible in real-time. Gone are the days of waiting for reports or manually updating spreadsheets. Imagine proactive adjustments based on real-time ladle locations, preventing bottlenecks and streamlining production.



Here's how YOLOv8 auto tracking addresses the limitations of manual tracking:

- **Accuracy:** By automatically identifying ladles based on painted numbers, YOLOv8 eliminates human error, ensuring accurate and consistent identification in real-time. This minimizes misidentification or misread numbers, ensuring reliable data for decision-making.
- **Timeliness:** The system operates in real-time, capturing and processing data instantaneously. This eliminates delays caused by manual observation, verification, and data

entry, providing immediate insights into ladle locations and movements.

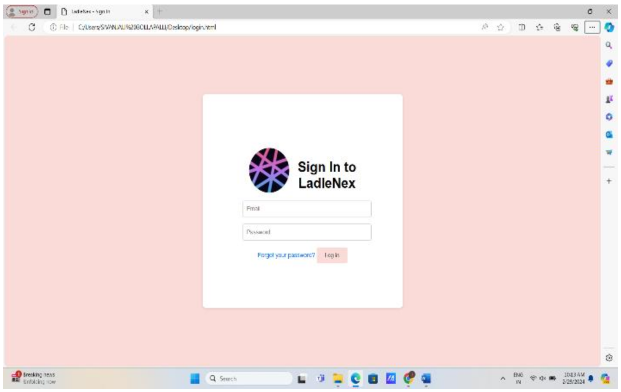
- **Data Availability:** Data is captured and transmitted directly to a central server, making it readily accessible for analysis and visualization. This real-time information empowers informed decision-making and process optimization without relying on outdated reports or spreadsheets.
- **Process Optimization:** With continuous location data, the system enables dynamic adjustments to optimize ladle flow, minimize wait times, and adapt processes based on real-time needs. This proactive approach can significantly improve operational efficiency and reduce production bottlenecks.
- **Performance Analysis:** The system's data granularity allows for precise calculation of key performance metrics like circulation times, life cycle analysis, and turnaround times. This empowers data-driven insights into ladle performance, enabling informed decisions on maintenance schedules, replacement strategies, and overall productivity improvements.

Beyond these core advantages, the YOLOv8 auto tracking system offers additional benefits:

1. **Scalability:** The system can be adapted to various production facilities and configurations, making it a versatile solution for diverse needs.
2. **Cost-effectiveness:** While initial investment might be present, the system's potential cost savings through improved efficiency, reduced downtime, and data-driven decisions can lead to significant long-term returns.
3. **Safety:** Real-time data and insights can contribute to proactive safety measures by monitoring ladle movements and potential hazards.

The YOLOv8 auto tracking system represents a significant leap forward in ladle tracking for steel production. By overcoming the limitations of manual methods, it offers a path towards improved accuracy, real-time data availability, optimized processes, and data-driven decision making, ultimately contributing to a more efficient, cost-effective, and safer production environment.

SIGN IN PAGE:

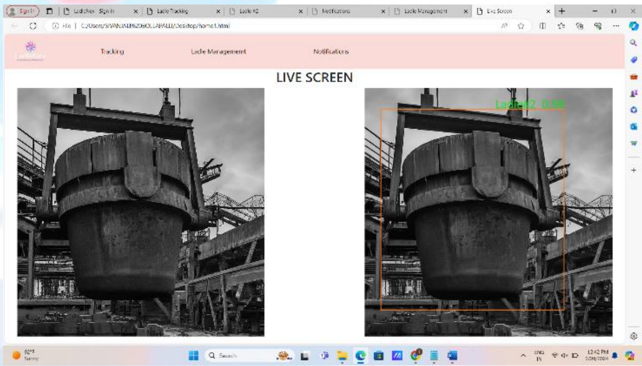


The image above is a screenshot of a sign-in page for our web application called "**LadleNex**."

Sign-In Page:

- Icon: Above the text, there's an icon consisting of colorful segments forming a circle.
- Email and Password Fields: Two blank fields for users to enter their email address and password.
- Forgot Password Link: Below the password field, there's a link for users who have forgotten their passwords.
- Log In Button: A button to proceed with the login process after entering credentials.

DASHBOARD:

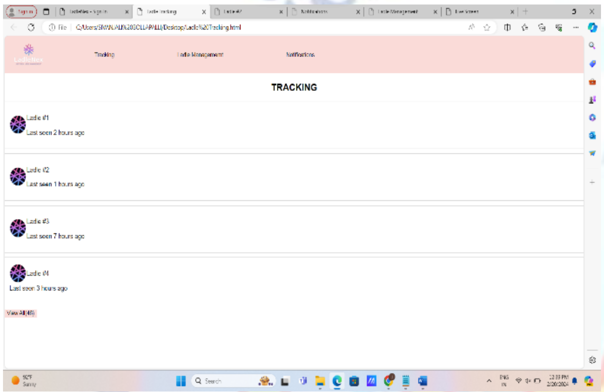


The Screenshot show a ladle being transported by a crane in a steel mill. The ladle is a large, cylindrical container used to transport molten metal. It is made of steel and has a thick lining of refractory brick to protect it from the heat of the molten metal. The crane is a large, overhead machine used to lift and move heavy objects. It has a long arm with a hook or magnet on the end.

In the Screenshot, the ladle is suspended from the crane hook and is being moved from one part of the steel mill to another. The ladle is filled with molten metal, which is glowing orange-red in the heat. The steel mill is a large, industrial facility where steel is produced from iron ore. The process of making steel involves melting iron ore in a furnace, then pouring the molten metal into a ladle and transporting it to another part of the mill where it is shaped and cooled.

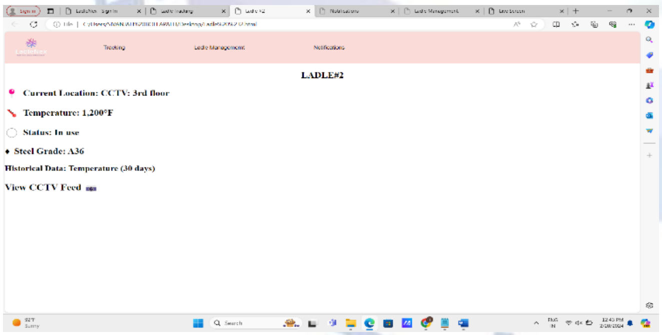
The ladle in right is being tracked. There is also a cc camera mounted near the ladle which is moving, which is likely one way the ladle is being tracked.Generally, there are multiple ways ladles are tracked in steel mills: Cameras and sensors: Cameras placed strategically throughout the mill capture the ladle's movement, feeding data to a central system. This is likely the case in the image you sent, given the presence of the camera.

LADLE TRACKING:



The image above shows a computer screen with a Ladle Tracking page open. The page shows the ladle IDs, last seen times, and a plus sign to expand for more information. In this we can track and manage the no.of ladles where they have been tracked last time with their timings. We can also see how many Ladle are there in the that time.

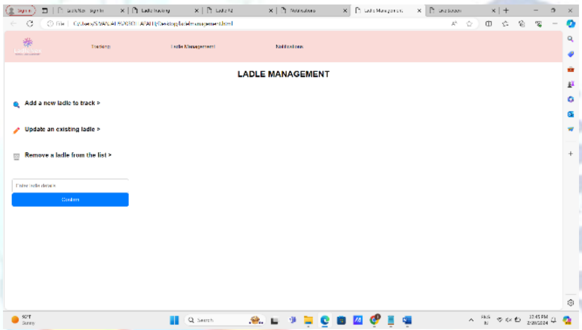
INFO ABOUT LADLE#2:



The image above is a screenshot of a displaying information about "Ladle #2

- Title: The screen is titled "Ladle #2," indicating that the information presented relates to this specific ladle.
- Current Location: Ladle #2 is currently located at " CCTV: 3rd floor."
- Temperature: Thcurrent temperature of Ladle #2 is noted as " 1,200°F."Status: - The ladle's status is marked as " In use."
- Steel Grade: The steel grade being used or contained in Ladle #2 is " A36."
- Historical Data Section: Below these real-time data points, there's a section titled " Historical Data" that displays the temperature history for the past "30 days."
- View CCTV Feed Button: At the bottom of the interface, there’s a button labeled " View CCTV Feed," presumably allowing users to view live footage of Ladle #2.

LADLE MANAGEMENT:

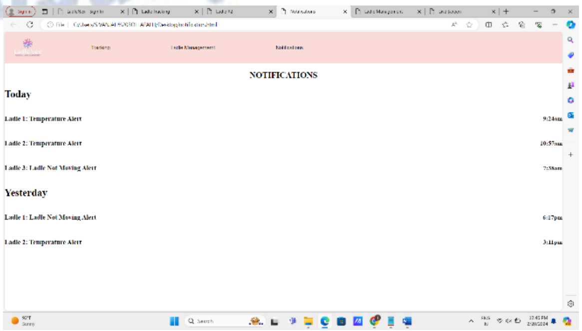


The Ladle Management screen allows users to add, update, and delete ladles. Ladles are used to track and manage the Ladles. The screen has four buttons:

- Add Ladle: This button allows users to add a new ladle to their account.
- Update Ladle: This button allows users to update an existing ladle.
- Delete Ladle: This button allows users to delete a ladle from their account.
- Confirm: This button allows users to confirm the action they have selected.

The screen also has a blue button at the bottom that says "Add Ladle". This button allows users to quickly add a new ladle to their account.

NOTIFICATION:



The image above is an interface showing notifications related to temperature alerts. The screen is divided into two sections: "Today" and "Yesterday." Each section contains notifications for three different ladles, numbered 1 to 3. The notifications indicate the specific ladle number and the time the temperature alert was received, which was 9:24 am for all six notifications.

1. Mobile Application Interface:

- The image displays a user interface of a mobile app.
- Specifically, it shows the notifications section.

2. Notification Section:

- The notifications are divided into two parts: "Today" and "Yesterday."
- Each section contains temperature alerts for three ladles.

3. Temperature Alerts:

- There are six notifications in total (three for today and three for yesterday).
- Each notification specifies the ladle number and the time of the alert (9:24 am).

CONCLUSION:

In this study, we propose an **automated tracking system** for ladles, leveraging the power of the **YOLOv8 algorithm**. Our system offers several advantages over traditional manual tracking methods.

- **Efficiency:** Real-time processing eliminates manual data entry and reduces human error.
- **Consistency**: Unique IDs for each ladle ensure transparent history and optimal filling levels.
- **Ladle Lifespan:** Automatic tracking enhances usability by monitoring thermal levels.
- **Scalability:** Easily integrated into existing infrastructure across various industries.

In summary, adopting an automated tracking system represents a significant leap forward in ladle management. It streamlines operations, enhances safety, and contributes to overall process efficiency. By embracing automated tracking, industries can achieve more efficient ladle handling and improved productivity.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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[1] YOLOV8: For algorithm -https://github.com/ultralytics/ultralytics
[2] COPILOT: For information and discription -https://copilot.microsoft.com