Automatic Rail Alignment

Team 2223

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Summary:

This team was tasked with keeping trailers for railway vehicles centered on the individual rails. Our job is to turn this currently manually done task to a fully automated process. Well not tasked with creating the final product our job is to determine a variety of methods to accomplish this task. The first part of solving the problem was to determine what type of information we need to keep the system in line. Our main information will come from ultrasonic sensors. These are the devices that are currently used to tell the operator if the trailer is starting to go off rail. However these sensors are limited to only knowing what is going on directly underneath the trailer. Without being able to look ahead it becomes impossible to predict how the system needs to move but instead is always reacting to what's happening. To fix this we determined two other types of sensors that could help look further down the line. The more robust sensor would be using an infrared camera to find the track. This would provide us with a lot of information about which direction the track is headed compared to its current direction. However machine vision can be a slow and complicated process and with the system being a trailer the cameras vision will get blocked quickly. The other future looking sensor would be a linear detection rod. By running one to each side of the track it would be easy to determine any bends in the track. The data coming from the linear detection rods are easier to read compared to the camera but they do lack the detail of the camera.

All of this information needs to be collected with the computing ultrasonic sensors already put in place; it would just be a matter of recording the additional sensor information and passing it all to another computer. This computer would do the calculation intensive part of the computing. It would receive the collected information and then compute what changes to the wheel system need to be made to keep the system centered. This information would be sent to a
final program where the directions are interpreted and applied to make the changes to the machine.

**Statement of Need:**

The sponsor (Nordco/Wabtec) produces rail inspection systems. These systems roll along rail lines at speeds up to 25 miles per hour and use ultrasonic sensors to detect faults and defects in the rail. The sponsor is seeking a methodology to locate the position between the rail and the wheels and work towards centering the wheel to within ±5 mm of the center of the rail. This methodology must account for the variations of the rail due to wear and damage as well as keeping the device centered around turns of the rail line.

**Project Description:**

**Method:**

There exist onboard sensors on the current production device. These transducers use piezo-electric devices emit ultrasonic waves (above 20kHz) which are not audible to the human ears at various angles to detect faults in the rail. One of these sensors is dedicated to detect the current alignment of the wheels on the rail. This information is displayed in the cabin for the operator to manually make adjustments to the alignment of the device on the rail. With the existence of ultrasonic sensors onboard the device already, the data from this sensor is already being collected and another ultrasonic sensor will not have to be implemented unless further ultrasonic data is needed. The downside to ultrasonic sensors is that the quality of the data depends on the placement and faults in the rail could have an effect on the accuracy of the time-of-flight data being collected. By only using a single transducer, the data could be strengthened
with additional transducers to collect additional rail alignment information just like how it is used for fault detection.

To increase the accuracy of the track location we have done research into a variety of sensors used for precise location. One of the options is to add a set of linear detection bars at the front of the trailer. We want to place the linear detection position sensor laterally between the track and the wheel. When the distance between the wheel and the track changes, the linear detection position sensor will capture the moving distance, direction and other information.

Compared with other methods of collecting information, the linear detection position sensor is more accurate and effective in collecting information. Since the linear detection position sensor only needs to determine whether the detection point is located at the "center" set by us, it does not need to process relatively "huge" data, so that when the track deviates, the system can respond quickly and help the train return to the correct track quickly. And also, the detection part of the linear detection position sensor is not exposed, it can work well in harsh environments.

The more versatile sensor we have thought of adding would be an infrared camera. Using the temperature difference of the railway compared to the surrounding ground the camera would provide an image of the rails future pathway. The camera provides large amounts of data that if analyzed properly can help to provide a very detailed plan on how the track is laid out. However using the camera has significantly more drawbacks then the linear detection rods. First the amount of data that needs to be sent with each image is significantly more than the linear detection rod. This would require either a more robust communication protocol or edge computing to reduce the amount of data sent. Both cause an increase in complexity and slow the analysis time giving a large possibility of going off track. The second problem with the camera is that weather can impact the ability for it to function. Especially in cold or rainy situations the
heat of the rail could be much harder to distinguish from ground. All of these problems would have to be taken care of in the coding which again could result in less accurate wheel settings.

All of the sensor data needs to be collected, analyzed, and then executed upon. The ultrasonic sensor data is already being collected by the current computing set up. The linear detection rod could be easily collected with any microprocessor with analog to digital conversion capabilities. Well the sponsor may require that the data collection code is written in a certain language, the current plan is to use C or C++ as it is quick and takes minimal storage to run. The information would then be sent over serial so the computing devices can be wired directly together. The reasoning behind this is because unless a router is added to the trailer there won’t be a reliable source of wireless connection and to keep within the constraints the data transfer needs to be quick and consistent. These data packets would then be received by a raspberry pi. The analysis will be done in python giving us a large variety of libraries to complete the analysis. The first priority is looking at the ultrasonic sensor to make sure the wheels haven't started to become off centered. Once confirmed the program would then use the information from one of the future looking sensors to determine if there is an upcoming turn or junction. Well this information does not need to be acted on immediately the information can be saved so when the ultrasonic sensors start showing a change the system already knows what way to turn. This program would output the distance the wheels should be from the center of the trailer and if the degree of camber. This information would again be packaged up and sent through serial communication to a final computer that can integrate with the machine. This final computer will be determined by the sponsor as well as the language it is programmed in. The goal of the program is to simply take what the previous program determined wheel setting and send the proper commands to the machine to create the same settings.
In regards to the budget of the project, there is no preliminary budget set. The sponsor does not require a hard deliverable, but instead, are looking for a methodology in order to implement the functionality they desire into their product. We may look to build a scale model to test out various methodologies of data collection, processing, as well as alignment procedure.
**Conclusion:**

In order to achieve our team's goal of keeping trackers for railway vehicles centered on the individual rails, we need to determine the way we collect information through research,
extract effective information through single or multiple information collection methods, and use it to realize the automatic adjustment of the track. Then we need to transfer the collected information to the computer for analysis to find out how to adjust the wheel to return to the center of the track when the track deviates. Finally, combined with the existing manual adjustment equipment, we need to design a method that can make the adjustment equipment receive the execution instruction and execute automatically. By receiving the analysis transmitted by the computer, we can adjust the wheel to keep the wheel in the center of the track.