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Remote-controlled cranes

UNB scientists use GPS technology to guide huge machines that move shipping containers

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(Photo Contributed)
These large cranes at an international shipping terminal in Korea are controlled by a GPS system designed by researchers at the University of New Brunswick.

The seaports of the world present a huge challenge to those who work there. Shipping containers, 20- to 40-feet in length, have to be stacked within inches of one another, and the slightest mistake could result in thousands of dollars in damage.

For that reason, two researchers at the University of New Brunswick in Fredericton research assistant Dr. Donghyun Kim and professor Dr. Richard Langley have developed guidance software to simplify the enormous, and potentially dangerous, task of guiding the movements of the port cranes who move the large shipping containers from one place to another. The two men, both of the department of geodesy and geomatics engineering, were contracted by Seoho Electric Company Ltd. of Korea to develop the GPS technology.

"Our task was to develop software modules so that the stationery cranes used in seaports could be steered using global positioning software modules," Dr. Langley says. "The way GPS technology works, data is taken from the base station and transmitted to the cranes. Then, the hardware and software inside the crane takes that data, interprets it and puts it on a map that the crane then uses to determine how it will work."

The development is the result of two years of intense research during which the researchers and the graduate students who were working with them built on the knowledge they had learned through other projects. One such project, Dr. Langley says, involved improving GPS accuracy to allow more accurate and efficient dredging of the St. Lawrence Seaway.

"It's very important that underwater clearance be maintained, so, periodically, navigation channels like the St. Lawrence Seaway must be dredged," he explains. "It's a tricky procedure, because you dont's want to take too much much sediment, but you do need to take out enough so that ships in the seawy wont's scrape along the ground."

To ensure that just enough sediment was removed from the bottom of the seaway, it was necessary to accurately determine the height of the silt in the seaway and how much clearance the largest ship would need to use the waterway. That's where the UNB team, working in conjunction with a team from Laval University in Ste-Foy, Que., came in.

"We knew the high accuracy of GPS could provide information we needed," Dr. Langley says. "We developed software to aid in that task, and that software became the starting point for the development of this crane steering software."

"This crane-steering software works in Real-time kinematic mode, also know as RTK, which is a GPS technique pioneered by surveyors and geodesists for efficiently determining the co-ordinates of points with high precision."

The technique is sufficiently accurate over short baselines that it can be used for machine control.

"RTK is a relative-positioning technique utilizing a GPS receiver at a reference or base station whose coordinates are known," explains Dr. Langley. "This receiver makes measurements which are then sent over a radio link to another GPS receiver, say on a crane, simultaneously making measurements on the same set of GPS satellites."

"By combining the reference station measurements with those from the crane, a computer on the crane can very precisely determine the crane's position and locate the crane on an electronic map of the area. Essentially, the software takes the data it gathers from the base station and transforms it into a set of grid lines the crane is permitted to follow, which keeps it from crashing into containers."

Thus, if the crane is moving to a certain location, the crane's steering system can direct the crane along a certain grid line using the GPS co-ordinates of the crane. The UNB system determine the position of the crane every one-tenth of a second with an accuracy better than two centimetres, with extremely high reliability.

"Actually," Dr. Langley adds, "there are two GPS receivers on each crane so that the computer on the crane can determine the crane's orientation as well as its position."

These developments represent a considerable advantage over even the most recent technology that has been used to direct cranes.

Standard mechanisms that were used prior to the development of this software to guide port cranes used cameras mounted on the sides of the cranes. These cameras relied on lines painted on the ground to keep the crane from running into one container while it was moving another. Another popular method included one in which the cranes followed guidewires buried in the ground.

"The problem with painted lines is that they have to be perfectly maintained," says Dr. Kim, who has been a research scientist at UNB since 1998. "Worn paint, rain, ice, snow any of these things could hamper the ability of that particular guidance system. There was also the challenge of camera lenses getting dirty."

"The nice thing about this new software is that it does not rely on painted lines," he continues. "Instead, it digitally maps the port and uses GPS to control the crane's actions. Since the system doesnt's rely on factors like paint that can wash away or lenses that can become dirty, it's much more accurate."

The GPS guidance software developed by Drs. Kim and Langley and the graduate students they work with is also much more cost-effective and easier to maintain than the more conventional methods of guiding port cranes, and that isnt's only with regard to the implementation of the system.

"This development is very encouraging in terms of what it could mean for the management of seaports," points out Dr. Kim. "Because the software allows for greater precision when moving these large containers, there is less chance that costly damage will be caused to expensive containers."

The new technology was developed almost exclusively by Dr. Kim, with some assistance from Dr. Langley and from the graduate students working in his department. The software was written and tested over the past year. Field-testing was completed this past spring.

The location of the field-testing site was in one of the container ports belonging to Seoho Electric Company Ltd., the same company who supported the development of the software, in Kwangyang, Korea. Dr. Kim travelled there with graduate student Sunil Bisnath and conducted the field-tests in May. Although testing was scheduled to take two weeks, the researchers encountered some difficulties, and the testing ended up takin more than a month.

"Everything went well in the lab, but it's easier there than in the real world," says Dr. Kim, who often stayed at the Korean test-site until midnight, returning to start the next day of testing five or six hours later at 5 or 6 a.m. "It's not until you get out in the field that you discover problems you had never anticipated in the first place."

But despite early challenges, Seoho is now marketing the new guidance system, and Drs. Kim and Langley are already researching the next generation of GPS-based guidance systems. Future sytems could include the ability to send GPS data over the Internet, allowing GPS base stations and remote receivers to operate at any distance.

"One way in which the work that we have done so far could influence work in the future may be in the monitoring of stability of the walls of mines, and the stability of the ground above mines," Dr. Langley says. "This could be of considerable benefit to the province of New Brunswick, where quite a lot of mining is done. It also illustrates how further research of GPS systems can forge a connection between two seemingly unrelated areas."
