



The Grand Canal in Digital Age

The Grand Canal has been flowing for 2,500 years. It still carries boats and water, and it still runs through cities. But keeping it in working order requires more than traditional maintenance today. It requires laser scanning to assess the state of every stone, sensors to detect the slightest movement, and data to make sense of it all.

Abubaker Hayaty, a doctoral student at Zhejiang University, has spent years studying how cultures communicate. His friend Ke Ning works at the Hangzhou Arts and Crafts Cluster and knows the canal's history intimately. Both have spent years around this waterway. But the technology now being used to protect it is new to both of them.

At the Beijing-Hangzhou Grand Canal Museum, a massive screen shows ancient workers digging the canal with primitive tools. "Seeing this introduction," Hayaty says, "I have come to appreciate the wisdom and perseverance of the ancient builders."

What he is about to see is how that ancient wisdom is being preserved with modern tools.

A bridge made of data

From the museum, they go to Zhejiang University. In a laboratory at the Cultural Heritage Institute, engineer Huang Shuo pulls up raw data from the Gongchen Bridge digital protection project on a screen. A complete 3D model of the bridge floats beside thousands of white points.

Huang explains that the technology is photogrammetry that uses algorithms to reconstruct photographed objects. The team used drones, ground cameras, and boats to scan the bridge from every angle. The result is a digital replica accurate to the millimeter. Researchers can now monitor the bridge's condition without touching it.

The data is stored in a server room where cluster computing systems handle the massive volume. "Regular computers can no longer meet our demands," Huang says.

Diao Changyu, deputy director of the Cultural Heritage Institute at Zhejiang University, explains: "We aim to transform physical artifacts, which are difficult to preserve forever,

into digital assets that can be copied and passed down permanently."

When Hayaty asks about AI, Diao says he is a technology optimist. In archaeology, many time-consuming tasks are being sped up, thanks to AI's power.

Monitoring a 110-km waterway

The digitization of one bridge is only the beginning. The Hangzhou section of the Grand Canal stretches 110 kilometers and contains 11 heritage elements. According to Shen Ying, deputy director of the Hangzhou Grand Canal Protection Center, these figures account for one-tenth and one-eighth of the entire Grand Canal system respectively. The canal passes through 27 cities.

Managing this vast heritage is complex. The canal runs through Hangzhou's urban core, tied to the lives of millions. This requires multi-departmental collaboration.

So Shen's team built the "Smart Canal" system, a digital platform that integrates data from multiple sources. It operates on a monitoring network called "Water, Land, Satellite, and Sky." But technology alone is not enough. Shen says some problems can be spotted only by going to the venue, doing a foot patrol. Sometimes plants grow in the bridge cracks, she explains. Tourists might see life and vitality in that, but if the roots grow too large, they damage the stones. That will eventually weaken the bridge itself.

Inspectors use what Shen calls "fingertip inspection." They compare pairs of images side by side, looking for changes. "When we spot a problem, we compare the left and right images to find differences," she says. "Those differences are the areas we need to monitor."

On the 428 boundary markers that define the protected area, small round devices have been installed. "That small device is like a digital armor," Shen says. "It is an online monitoring module."

Gongchen Bridge has a structural monitoring module. Blue markers on the 3D model indicate cracks or subsidence identified over years of monitoring. It is like taking the

bridge's pulse and diagnosing its condition, Ke explains.

At Fengshan Water City Gate, the only surviving water gate among the 15 built in the Yuan Dynasty, monitoring is more precise. Researchers collect data on subsidence, bulging, arch deformation, and cracks. Hu Chaoqiao, deputy head of the Heritage Monitoring Department of the Hangzhou Grand Canal Protection Center, says they use a four-color early warning system to denote the level of danger: red, orange, yellow, and green.

A small inclination sensor functions like a nerve ending. "In the near future, it will transmit changes to our Smart Canal platform 24 hours a day," Hu says. "This is not merely an upgrade. It is a key advancement for the entire monitoring system."

From the lab to the public

Technology serves not just experts but millions of visitors.

At the Beijing-Hangzhou Grand Canal Museum, Deputy Director Xia Handan shows Hayaty a 26-meter-long scroll depicting the canal's route during the Qing Dynasty. "The painting uses text to label each location," she explains. "We can trace which cities and water facilities the canal passed through."

A data platform lets visitors explore the canal's story. "We have gathered scattered information on this screen," Xia says. "Visitors can explore food, scenery, and customs, and learn how the canal changed daily life."

At the Hangzhou Arts and Crafts Museum, 351 artifacts have been digitally preserved through 360-degree scanning. "Visitors can select an artifact and view its complete digital record," Ke says, "including name, age, and a rotating 3D image."

"Is it possible I won't need to come to the museum at all in the future?" Hayaty asks. The answer is yes. The museum already offers 360-degree virtual tours on its website and WeChat account.

Legends on the water

The most dramatic fusion of technology and experience

happens on the water.

At Wulin Gate, Hayaty and Ke board a boat for an augmented reality (AR) water tour, launched in October 2025. Passengers wear Rokid's AR glasses that blend real scenery with animated stories about the canal's legends.

Shen Jiahuan, a Rokid representative, explains: "We dug deep into the cultural stories behind each scenic spot and produced animations. With our Optical See-Through solution, you see both the real scenery and the animated stories."

A central control system manages the experience. "At important scenic spots like the Xiangji Temple and Gongchen Bridge, all passengers see the same story at the same time," she says. "This creates shared cultural resonance."

Li Linwei, spokesperson of the Hangzhou Water-Land Transport & Tourism Development Group, says the tour started last October. "Visitors used to only hear stories from the tour guide. We wanted them to experience it visually. So we added AR glasses to blend virtual stories with real scenery."

As the boat returns, Hayaty reflects that the Grand Canal is a living cultural heritage. "We use technology to record it, understand it, and protect it. Technology helps us observe it from perspectives we've never had before," he says.



Part of the Beijing-Hangzhou Grand Canal in Hangzhou. (COURTESY PHOTO)



Along the Grand Canal in Hangzhou, east China, cargo boats make their way to different destinations, just as they have been doing for centuries. Along its banks, people buy coffee or practice tai chi. The canal is not a museum piece. It is still part of people's lives.

On the arch of Gongchen Bridge, a 17th-century stone structure first built in 1631 that has witnessed nearly four centuries of Hangzhou's history, two people look out over the water. One of them, Ke Ning, works at the Hangzhou Arts and Crafts Museum, one of a cluster of canal-side museums dedicated to the crafts that flourished along this waterway. She walks beside the canal every day and crosses it on her way to work. Beside her stands Abubaker Hayaty, who came to China from Sudan nearly a decade ago and now lives in Hangzhou, where the Grand Canal ends its long journey from the north. Over the years, he has watched the boats pass and regards the canal as a living waterway that still shapes the city around it.

Ke asks him, "You see the bridge and the flowing water. But do you truly perceive what this canal means for this country, for this civilization?"

One canal, half a civilization

If you look at the map of China, most of its major waterways, the Yellow

A Canal of Civilization

River, the Huaihe River, the Yangtze River, and the Qiantang River, all flow eastward. China's geography is naturally divided into north and south. But one waterway runs north-south, connecting what geography had separated. It is the Grand Canal, the world's longest artificial waterway, connecting Beijing in the north to Hangzhou in the east. The first section of the canal, the Han Gou, was dug in 486 BCE to connect the Yangtze and Huai rivers. Later dynasties extended it.

The Sui Dynasty (581-618) united it into a north-south waterway. The Yuan Dynasty (1271-1368) rerouted it, creating the Beijing-Hangzhou Grand Canal we know today. The over 1,700 km waterway links five major river systems into one network: the Haihe River, Yellow River, Huaihe River, Yangtze River, and Qiantang River. There is a saying among Chinese historians: "One canal, half a civilization."

From the Tang (618-907) and Song (960-1279) dynasties onward, China's economic center gradually shifted south, while the political capital remained in the north. The canal bridged this divide.

In the Northern Song Dynasty (960-1126), millions of tonnes of grain traveled the canal each year to feed the capital at Kaifeng, now in Henan province in central China. In later dynasties, the system continued, with grain boats sustaining the northern capitals. Without this supply line, national unity could not have been maintained.

The canal and the economy

The canal was first built to move grain, but it soon carried more than grain. By the Tang and Song dynasties, private merchants were loading their own goods onto

the barges that carried official shipments. Silk from the south, tea from the hills, and porcelain from the kilns moved north along the water. Northern goods traveled south in return. The canal turned a collection of regional economies into something larger.

Along its banks, market towns grew into cities. Huai'an, Jining, Linqing, Cangzhou, and Tongzhou became wealthy not only from the land around them, but also from the boats that passed through.

Ke points across the canal to the museum complex where she works. "The fans, the umbrellas, the swords were industries, not just art. They fed families. The craftsmen shipped their goods along this water to buyers hundreds of miles away. The canal was their market."

For the millions of people who lived along its banks, the canal was a lifeline. It carried what they made and brought what they needed. It connected them to a world beyond their village.

The canal and culture

People and skills traveled the canal too. Northerners brought wheat and farming methods south. Southerners carried their dialects and cooking north. Along the banks, these cultures met and changed one another.

The canal passes through five distinct cultural regions: the Yan-Zhao culture of the north, the Qi-Lu culture of Shandong, the Central Plains culture, the Huaiyang culture, and the Wu-Yue culture of the south. Before the canal, these regions were largely separate. The canal brought them together. It also linked the maritime Silk Road with the

overland Silk Road, connecting China's coastal trade to its continental networks.

The literary imagination followed the water. The classic *Dream of the Red Chamber* opens in the canal city of Suzhou. Lin Daiyu, the heroine, travels the canal from Yangzhou to Beijing, a journey that sets the story in motion. Kunqu Opera began in Suzhou and Yangzhou, then spread north along the canal. Peking Opera traveled the same route, carried by troupes from the south. Food traveled too. Dumplings met wontons. Along the canal, these traditions met and became something new.

Back to the bridge

As dusk falls, Ke and Hayaty return to Gongchen Bridge. The early summer light has softened.

Hayaty is silent for a moment. Then he says: "Before today, I thought I understood what a waterway could be. Now I see it differently. This is a canal of civilization. It carried more than boats. It carried a civilization over the course of centuries."

He looks down at the water. "And it belongs to ordinary people. It was built for them to use and live beside. The craftsmen, the merchants, the families who washed clothes on these stone steps kept it alive. They still do."

Ke nods. "The builders were not thinking about creating a landmark. They had practical problems to solve, keeping the capital fed and moving goods across the country. But they built something that outlasted them."

Behind them, the canal flows on. A boat moves slowly past. Living heritage is not a label. It is the way this canal has always been.



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