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Voting in CAD for Mammography

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Computer-aided detection (CAD) uses software and computers to bring suspicious areas on a mammogram to the radiologist's attention. According to the American Cancer Society, early research suggests that CAD systems help radiologists diagnose more early-stage cancers than mammograms alone. But some doctors disagree about the accuracy of identifying cancers with CAD software. Some feel that CAD devices are not as effective as simply having a second radiologist review films or digital images (double reading), due to the occurrence of false positive identification of benign breast changes, deemed suspicious. However, single reading is already a primary screening method used in the United States and double reading is declining in Europe since fewer radiologists are entering the mammography field.

Despite this, many radiologists are dubious regarding CAD because of the occurrence of a high number of falsepositive marks on CAD interpretations. The incidence of a large number of false-positive marks by a CAD system (with current rates 5 - 10 times higher than those of radiologists) can significantly hinder its usefulness by distracting the interpreting radiologist. A significant reduction in false-positive rates is required in order for CAD to become comparable, performance-wise, to the opinion of a second radiologist.

CAD and False Positive Rates

It is possible to reduce the false positive rate and increase sensitivity, by combining the individual results of multiple engines and employing a voting mechanism that considers each. However, developing a voting scheme and algorithms to provide improvement for a particular combination of engines is a challenging task, requiring special aptitude and experience. The number of engines included in voting schema, their types, key expertise, accuracy of each engine are just a few factors that have to be considered in choosing the right voting algorithm. In particular, it is very important to analyse whether or not the engines use similar approaches and whether they produce different or similar types of errors. Engines using similar approaches to recognition and producing similar types of errors are called non-orthogonal. Engines based on varying methodologies and, therefore, making different errors are referred to as 'orthogonal'. Voting schemes and algorithms are very different from non-orthogonal and orthogonal engines.

In any case, voting algorithms are uniquely created to homogenise results of particular engines, focus on individual engines' strengths, avoid their weaknesses, and suppress unimportant results. In some cases voting eliminates the results of an engine or algorithm altogether; in others it combines them with the results of others. Successful medical imaging technologies need to consider the strengths and weaknesses of particular engines, their peculiarities and individual characteristics and other factors. Employing nonoptimal voting algorithms may not bring about an improvement of results and may even deliver poor performance.

The First Applications of Voting Methodology.

The implementation of a powerful combination of engines using a number of fundamentally different algorithms and techniques was initially applied in the postal automation industry. A combination of a human-like holistic analysis, multiple neural networks and sophisticated statistical voting algorithms enabled a significant improvement in recognition rates and a decrease in error rates in mail processing.

These advancements in mail automation were first achieved in 1998, when the Remote Computer Reader (RCR) applied by the United States Postal Service recognised about 35 percent of machine printed and two percent of handwritten letter mail pieces. Thanks to the use of voting methodology modern systems recognise 93 percent of machine printed and about 88 percent of handwritten letter mail – or more than 90 percent cumulatively. Similarly, the application of multiple engines in a voting scheme for the banking and financial services industry raised the read rates in payment automation from 40 percent in 1997 to 80 percent at a one percent error rate today. The universality of these algorithms and methods makes them fully applicable to the medical imaging market.

Voting in Medical Imaging

Multiple, parallel recognition processes offer technological advances in medical imaging. Each image recognition process may identify areas of interest on the mammogram image independently, without sharing information with other image recognition processes. Image recognition processes might also work together to identify different areas of interest. After image recognition processes individually identify areas of interest or objects on the mammogram image, the different areas can be compared to determine a confidence value related to the accuracy of the identifications.

The comparison can be done using a voting process. Comparing the results of multiple image recognition processes allows for the mitigation of the inherent faults of the image recognition process, thus leading to reduced false-positive and false-negative rates. Additionally, methods utilising multiple image recognition processes, rather than a single one, amicably lend themselves to multiple processor systems or networks. Thereby, they allow image recognition processes to be determined in parallel, increasing computational efficiency and spreading the workload across multiple processors. The result is fast and produces accurate actionable information.

The voting mechanism experience in other markets suggests that utilising multiple image recognition processes is the most efficient means by which superior performance can be delivered to the market. In fact, this same experience shows that not using such an approach rapidly becomes a competitive disadvantage to the supplier that does not offer it to the market once it becomes available and accepted. The reduction of false-positive readings achieved through voting methodology in medical imaging could ultimately result in decreased medical costs, emotional stress, follow-up examinations and recalls. It is only when CAD systems achieve sensitivity and false-positive rates approaching those of a radiologist that they will be embraced as a second opinion tool with no hesitation.

Facts on Breast Cancer

The chance of developing invasive breast cancer is about 1 in 7 (13.4 percent). The National Cancer Institute estimates that there were 207,090 new cases detected and 39,840 women died of breast cancer in 2010. While in the past approximately only 75 percent of women diagnosed with breast cancer survived five years after detection, today nearly 90 percent of women diagnosed with breast cancer will survive their disease five years after detection. This increase in survival rates is largely attributed to advanced treatment methods and routine mammography screening, including CAD systems.

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