Applications of artificial intelligence in Ultrasonography

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Preamble

- Medical artificial intelligence (AI) gained attention with the advent of IBM Watson Health (Kim et al, 2022).
- Efforts to refine and apply AI to clinical practice are more active than ever.
- AI applications are being commercialized like big data, deep learning, artificial neural networks (ANNs) for analyzing medical images has been recognized.
- Machine learning is a basic method of AI that uses data, learns from the data, and makes decisions or predictions by itself.
- Deep learning is a subtype of machine learning, through which ANNs themselves can judge the accuracy of predictions.
- Deep learning have extended beyond computed tomography, magnetic resonance imaging (MRI), ultrasonography (US), and pathology slides to include determinations of disease severity using endoscopy, including optic and intestinal images.
- Diverse companies have been developing and commercializing AI-based video platforms.

Artificial Intelligence

- AI was first introduced in the 1960s with the goal of using complex machines (i.e., computers) to simulate human intelligence.
- AI technology has been advanced through machine learning and deep learning.
- Machine learning receive data and learn for themselves without being programmed with rules.
- Deep learning involves models constructed to analyze large amounts of data using ANNs, which are structured into multiple neural nodes, resembling the arrangement of neurons in the brain.
- For video and image processing, convolutional neural networks have been applied in deep learning; these contain deeper networks with more convolutional layers and have the ability to integrate information more deeply for image processing.

AI in Ultrasonography

- AI is being applied and actively studied in obstetrics for the analysis of US, which generates standardized data. US is a safe, non-invasive checkup method for prenatal diagnosis.
- Measurements are challenging in circumstances such as maternal obesity, motion blurring, missing boundaries, acoustic shadow, speckle noise and a low signal-to-noise ratio.
- The use of new technologies to improve the primary acquired images or help extract and standardize measurements is of great importance.
- Machine learning was first applied to US images of fetuses several years ago.
- It has become possible to distinguish different body parts of fetuses through machine learning; therefore, algorithms have been developed that automatically extract and measure fetal structures and fetal biometry from US images.
- Machine learning has helped in the identification of fetal structures and organs to find congenital abnormalities.

Fetal echocardiography

- Fetal echocardiography (ECG) has only been used for 15 years.
- FECG is essential for perinatal care and for monitoring intrauterine growth restriction, twin-to-twin transfusion syndrome, and congenital heart anomalies.
- FECG is challenging due to involuntary movements of the fetus, the small fetal heart, the fast fetal heart rate, limited access to the fetus, and the lack of experts in fetal echocardiography.
- Automatic calculation of the fetal heartbeat has been carried out in many studies that have extracted the fetal heart rate from cardiotocography (CTG) using dimensionality reduction or measured fetal QRS waves complexes from maternal ECG recordings using ANN and pulse-wave Doppler envelope signals extracted from B-mode videos.
- For cases with congenital heart anomalies, an intelligent navigation method referred to as "FINE" was developed and this can detect four types of abnormalities.

Other applications

- Estimation of gestational age and prediction of preterm birth, aneuploidy, and asymptomatic short cervical length have been investigated using machine learning algorithms.
- An effective system was developed for predicting fetal brain abnormality.
- Deep learning-based automatic measurement programs for parameters indicating the progression of labor (e.g., the angle of progression) are currently applied.
- Measurements of amniotic fluid are susceptible to errors between measurements, which can affect treatment decisions, and AI-based programs that can automatically measure these items are being developed.
- AI-based programs can be helpful for measurements that require evaluators to be fully trained and experienced, such as nuchal translucency, and these techniques may be combined with a robot arm that performs the scanning to automatically extract standardized fetal imaging views.
- AI methods in medical care could facilitate individual pregnancy management and improve public health, especially in low- and middle-income countries.