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| **Title:** | Intelligent Diagnosis System for Children’s Growth and Development Based on Deep Learning Technology |
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| **Abstract:** | In recent years, with economic development and social progress, pediatric endocrine system diseases have attracted more and more attention from the society, parents, children and pediatricians.The occurrence of these diseases is closely related to genetic factors, environmental factors and lifestyle. If not treated in time, they will bring many adverse effects on the physical development, psychological development, schooling, employment and marriage of the patients with these diseases. The key to early interventional therapy is to objectively evaluate the development of children through bone age measurement.The care.ai™ Child Growth and Development Intelligent Diagnosis System is developed by Yitu Healthcare based on massive real clinical data from several top medical institutions. It supports three bone age measuring methods: TW3, CHN 05 and GP mapping. With month-level accuracy, it realizes second-level response, and can provide a complete growth and development monitoring report. At present, the system has been put into trial use in hundreds of medical institutions in China, supporting local or cloud platform deployment. In addition, it has gradually penetrated out-of-hospital scenarios such as physical examination and become an indispensable AI tool in the field of pediatrics. This paper will try to elaborate on the great value of this system in the field of children's growth and development monitoring. |

# Overview:

For the interpretation of bone age images, there are international G-P mapping method, TW3 scoring method and China’s CHN method, TW3-C method and Ye’s method modified based on TW2 or TW3. Among them, the G-P mapping method is simple, intuitive and time-saving, but it is subjective and inaccurate. TW3 is a preferred method in scientific research. Although TW3 method is accurate, it is cumbersome, time-consuming and difficult to implement in clinical practice. Especially in recent years, the rapid increase in the number of bone age measurements has brought great pressure for pediatricians to read images, and clinical diagnosis and treatment are facing challenges.

care.ai™ Child Growth and Development Intelligent Diagnosis System, with the help of Yitu Healthcare’s advanced image recognition and artificial intelligence technology and deep learning based on the bone age determination experience of top experts in China, is capable of accurately and rapidly interpreting children's bone age images and reaching the diagnostic level of senior professional doctors.On the basis of the machine’s diagnostic results, doctors can quickly generate the bone age evaluation report to patients. It greatly improves doctor’s working efficiency and diagnostic accuracy.

# Impact

Intelligent Diagnosis System is of unprecedented importance in the field of global child growth and development monitoring:

In China alone, the number of children aged 0–14 is as high as 260 million, while there are only 135,000 pediatricians (according to the data in 2014). On average, one pediatrician needs to serve an average of 2,600 children. Not only are high-quality pediatric medical resources scarce, but also the distribution is seriously uneven. Most of the high-quality pediatricians are located in professional pediatric clinics and top cities. However, with limited medical professionals and professional level, the monitoring of children’s growth and development in the vast developing regions needs to be improved urgently.

Once the growth and development problems such as dwarfism and precocious puberty are neglected and are not treated in a timely manner, they are very likely to endanger children’s physical and mental health, have a serious impact on their learning, family, even future work and marriage, and bring heavy psychological burden to children and parents. It is very important to improve the national monitoring capacity for children's growth and development through AI tools and to increase the accessibility of high-quality medical resources.

The great value of this AI product mainly includes:

**1. Improve the efficiency of diagnosis and treatment in top medical institutions.**

Accurate determination of bone age is the basis of endocrine disease diagnosis and intervention in children. Take the internationally-agreed TW3 method as an example. It takes at least 15–30 minutes to evaluate the growth and development of 20 hand bones in detail, score them and calculate the bone age, which puts great pressure on pediatricians. Chinese pediatricians are extremely scarce. Each pediatrician has to serve more than 30 patients every half day. It is impractical to take a lot of time to calculate the bone age, but the care. ai™ Child Growth and Development Intelligent Diagnosis System only needs a few seconds to read a bone age image and can produce a complete child growth and development monitoring report. The diagnostic efficacy is exponentially improved.

**2. Improve the accuracy and consistency of clinical diagnosis and treatment.**

Bone age scoring highly depends on the proficiency of individual clinicians. Bone age interpretation by different clinicians and at different time points may contribute to variations of 3–6 months or even one year. However, bone age AI system based on deep learning technology can achieve the consistency of bone age interpretation by different doctors in different medical institutions, different regions, and even different countries. In small-scale clinical trials, the bone age interpretation of AI system reaches the month-level accuracy, which is comparable to that by senior pediatricians. At the same time, standard child development reports can also improve the inconsistency of diagnostic terms in different areas.

**3. Activate clinical data to realize intelligent scientific research and teaching based on AI.**

As an efficient and accurate monitoring tool for children's growth and development, AI system provides data accumulation for the research of bone age and children's growth and development in hospitals. Clinical experts can systematically understand the actual growth and development of Chinese children, establish local bone age standards, and realize the clinical and academic value. At the same time, AI system can also help junior doctors learn, promote personnel training, and accelerate the growth of young doctors.

**4. Support multiple deployment requirements and flexibly match application scenarios.**

The Child Growth and Development Intelligent Diagnosis System can support local deployment and cloud platform deployment in order to meet the different needs of different medical institutions for deployment, especially in remote areas or primary level medical institutions where the number of children is relatively small. Cloud platform deployment can significantly reduce costs.

**Existing Work**

The traditional bone age calculator requires pediatricians to evaluate the development of 20 hand bones manually and score them before sending the data into the bone age calculator for calculation. It is time-consuming and the accuracy cannot be guaranteed.

care.ai™ Child Growth and Development Intelligent Diagnosis System is developed independently by Yitu Healthcare. At the very beginning, it only supported TW3 method, but now it supports three methods of bone age interpretation: TW3 method, CHN 05 method and GP mapping method. It can support seamless switching of various bone age interpretation methods, and automatically generate monitoring reports on children's growth and development. The accuracy of interpretation is comparable to that by senior pediatricians. It has also achieved an exponential upgrading in image reading efficiency.

This system has four functions: intelligent bone recognition, accurate scoring, second-level diagnosis and structured report. It supports automatic sketching and recognition of ossification center of hand bones, accurate counting; automatic intelligent grading of each hand bone to calculate the final bone age; automatic generation of text reports seen in images for doctors’ reference. In view of many commonly used endocrine indicators in children, the system automatically generates detailed and complete diagnostic reports, including bone age evaluation, height evaluation, height prediction, development evaluation and other indicators. Based on the bone age measurements accurate to month, combined with historical follow-up data, the system can monitor the growth trend and clinical efficacy evaluation in an all-round way.

The system is installed and operated in the hospital intranet environment to ensure data security to the greatest extent. Used in connection with RIS and PACS, it is embedded in the clinical workflow so that doctors can read images using the original computer without changing the original operating habits. At the same time, the system reduces the time of bone age image reading from 20 minutes to less than 1 second, which effectively reduces the workload of radiologists and endocrinologists. While greatly improving the efficiency of doctors, based on high accuracy, the system unifies the several measurements for the same image, avoiding subjective errors.

According to different deployment environments, the AI system can also support cloud platform deployment, provide more flexible deployment methods for primary level medical institutions, reduce deployment costs, and enable more children to enjoy the growth and development monitoring services of top medical institutions.

# Feasibility

Market feasibility analysis of Child Growth and Development Intelligent Diagnosis System:

1. The patient base is large and the demand is exuberant. In China alone, there are 260 million children, while only 135,000 pediatricians. The contradiction between the extreme shortage of pediatricians and the growing needs of parents for growth and development monitoring is becoming increasingly evident. With the development of economy and the awakening of health consciousness, parents’ need for diagnosis of endocrine diseases such as dwarfism and precocious puberty is bound to increase rapidly.

2. The product has excellent performance and obvious clinical value. In the past, it took 15–30 minutes for a senior pediatrician to read a bone age image, but now it only takes the AI system a few seconds to complete it with month-level accuracy and a high degree of consistency. It improves the efficiency of the bone age image reading in a revolutionary manner. An AI system can save a lot of time used to read images and to write growth and development report for hospitals.

3. It has great generalization ability and can be widely applied. care.ai™ Child Growth and Development Intelligent Diagnosis System has shown a high degree of generalization in clinical practice. It has achieved surprising accuracy in medical institutions at different levels in many provinces and cities, which is extremely rare for similar AI products, and even in the whole medical AI field. At the same time, the emergence of intelligent cloud platform for children's health is conducive to the convenience of primary level medical institutions to obtain AI support.

At present, the AI system has been put into trial use in more than 100 medical institutions in China, providing growth and development monitoring services for tens of thousands of children. It is also useful to build an intelligent cloud platform for children's health and benefit the primary level medical institutions with advanced AI products in the form of cloud platform.

# Data Availability

The R&D data set of this system, containing hundreds of thousands of entries, comes from top pediatric medical institutions in China. All the data are completed by more than 100 pediatric specialists under a special quality control system, and are updated iteratively in the course of clinical trials. During the training process, Yitu Healthcare attaches great importance to data security and patients’ privacy protection, abides by the highest ethical standards and all data are automatically desensitized and run in the internal environment of hospitals strictly in accordance with the principle of “data remains in hospital”.

# Benchmarking

*Data quality control.* Yitu Healthcare has a special annotation quality management system, a professional annotation website, and an annotation team composed of more than 100 professional pediatricians. The annotation quality has been strictly corrected to ensure that it meets the needs of clinical diagnosis and treatment.

At present, our indicators for evaluating the effectiveness of the algorithm are mainly the interpretation accuracy of the 20 hand bones, and the comparison between the results of AI and those of clinicians.

The AI system has been widely validated in more than 100 medical institutions in China. Its accuracy and generalization are excellent.

# Organizer Details

Yitu Healthcare Medical brings together the world’s top AI scientists, big data cloud computing industry experts and senior medical experts. It is committed to rapidly embedding medical AI products into clinical workflow to help medical institutions improve the level of medical services and optimize their diagnostic and therapeutic capabilities.

At present, Yitu Healthcare has introduced full-stack medical intelligent products and solutions such as the care.ai™ Child Growth and Development Intelligent Diagnosis System and gone deep into the disease prevention, examination, diagnosis, treatment, follow-up, scientific research and other processes. Its care.ai™ series artificial intelligence products have been put into trial use in more than 200 3A hospitals and covered regional medical centers in some provinces and cities. It has rich experience in definition, development, engineering and deployment, operation and maintenance of medical AI products.

China is facing severe medical challenges, but Yitu Healthcare believes that the future of AI lies in healthcare.

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