ROBOTICS AND BIOMEDICAL ENGINEERING AND ITS APPLICATION AND HISTOLOGY

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Introduction

Sovremennaya meditsina stremitelno razvivaetsya blagodarya integratsii injenernyx i informatsionnyx tehnologiy. Odnim iz klyuchevyx napravleniy etogo protsesa yavlyaetsya **biotekhnicheskaya ingenieriya (biomedicine engineering)** , which will be completed in biology, medicine, physics and robotics.

Robotics is interested in a specific place and sphere, as it allows the creation of accurate, automated and safe systems for diagnostics, analysis and treatment. V poslednie gody robotizirovannye tehnologii aktivno vnedryayutsya ne tolko v chirurgii ili protezirovanii, no i v takikh fundamentalnykh oblastyax, kak **histologiya** — nauka o mikroskopicheskom stroenii tkaney.

Tsel dannogo doklada — rassmotret rol robototechniki v biomeditsinskoi injenerii, eyo primenenie v histologicheskix issledovaniyakh i perspektivakh razvitiya cifrovoy histologii na osnobe robotizirovannyx tekhnologiiy.

1. Biomedical engineering and robotics: current situation

Biomedical engineering is a multidisciplinary field that develops and applies engineering principles for solving medical problems. Odnim iz eyo napravleniy yavlyaetsya **robotics** , kotoraya ispolzuetsya dlya sozdaniya automatizirovannyx system:

- surgical robot;
- rehabilitation complex;
- diagnostic and laboratory facilities;
- micromechanical devices for tissue and cell analysis.

V otlichie ot traditsionnyx instrumentsov, robotizirovannye sistemy obespechivayut:

- sverkhvysokuyu tochnost dvizheniy;
- minimization of the human factor;
- work capacity in sterile and cold conditions;
- increase in speed and productivity.

2. Histology and eyo mesto in modern medicine

Histology is a fundamental medical discipline that focuses on the microscopic structure of human tissues and organs. Ona lejit v osnove ponimaniya patologicheskikh protsesov i diagnostiki zabolevaniy.

The process of histological investigation includes several stages:

1. **Preparation of biological material** (fixation, obesvojivanie, zalivka v paraffin);
2. **Microtomy** — poluchenie tonkikh srezov tkani;
3. **Coloring preparations** for the visualization of structural elements;
4. **Microscopy and image analysis** .

Eti etapy traditsionno vypolnyalis vruchnuyu i bovavali vysokoy qualificatsii, vremeni i tochnosti. Odnako razvitie robototechniki i tsifrovyx tehnologii znachitelno izmenilo etot process.

3. Primenenie robotics and histology

Sovremennye laboratories actively use **robotizirovanny systems** for automatization of all stages of histological analysis. Рассмотрим основные направления.

3.1. Robotizirovannaya podgotovka histologicheskikh preparatov

Spetsialnye avtomaticheskie stantsii vypolnyayut fiksatsiyu, zalivku, narezku i okrashivanie tkaney bez uchastiya cheloveka. Preimushchestva:

- sokrashchenie vremeni obrabotki materiala;
- snienie oshibok i zagryazneniy;
- tochnost dozirovaniya reactivov;
- povyshenie bezopasnosti personala.

Examples such system — **Tissue-Tek Prisma** , **Leica ASP300** , **Sakura Smart Stainer** .

3.2. Microroboty and nanoroboty

In experimental biomedicine, **nanorobots are actively developing** , capable of manipulating individual cells or tissue structures.
It is used for:

- tissue microdissection;
- tochechnoy dostavki krasiteley;
- nablyudeniya za dynamic processes and cells and real time.

3.3. Robotics for digital microscopy

Sovremennye **robotizirovannye microskopy** sposobny avtomaticheski scanirovat preparations, fokusirovatsya i peredavat izobrazheniya v bazy dannyx. Eti isobrazheniya zatem analiziruyutsya s pomoshchyu algoritmov iskusstvennogo intellecta.

Tak sozdayutsya **tsifrovye biblioteki histologicheskikh preparatov** , kotorye ispolzuyutsya v uchebnyx celyax i nauchnyx issledovaniakh

4. Robotics and artificial intelligence and digital histology

Sovmeshchenie robototechniki i iskusstvennogo intellecta stalo klyuchom k sozdaniyu **digital histologii** .

AI algorithm can:

- classification of tissue types;
- raspoznavat pathological changes (opukholi, vaspalenia, etc.);
- проводит количественный морфофилоческий налаз;
- obuchatsya na millionakh izbrajeniy, postoyanno uluchshaya tochnost diagnostics.

Roboty obespechivayut **sbor i podgotovku dannyx** , a iskusstvennyy intellect — **analysis** .

Vmeste oni sozdayut edinuyu intellectual system histological diagnostics.

5. Role of robotics and educational processes in histology

Application of robotic technology in **medical education** . Students can help with robotic microscopes, 3D models and virtual simulators:

- izuchat structural fabric in interactive form;
- проводит virtual experiment;
- work with real digital preparations, created robotic systems;
- development of analytical skills, necessary for morphological research.

In my opinion, robotics does not only oblegchaet issledovatelskuyu deyatelnost, no i makes the training process more visible and modern.

6. Preimushchestva i perspektivy nedreniya robotics and histology

Advantages:

- vysokaya tochnost i vosproizvodimost rezultate;
- snienie human factors and lovers;
- economic time and resources;
- uluchshenie bezopasnosti laboratornykh protsesov;
- vozmojnost distance analysis and training.

Prospects:

- sozdanie polnostyu automatizirovannyx histologicheskikh laboratory;
- integration of robotics and technology of iskusstvennogo intellecta i bolshikh dannyx;
- razrabotka microrobotov dlya issledovaniya vivyx tkaney *in in vivo* ;
- ispolzovanie robotizirovannyx system for individualized medicine and oncodiagnostics .

7. Problems and challenges

Nesmotrya na ochevidnye dostizheniya, nnedrenie robototechniki v histologiyu soprovojdaetsya ryadom problem:

- vysokaya stoimost oborudovaniya;
- neobhodimost obucheniya personala;

- slojnost integratsii different digital system;
- eticheskie i pravovye voprosy, svyazannye s obrabotkoy biologicheskix dannyx.

Reshenie etix voprosov potrebeet sotrudnichestva engineers, doctors, biologists and IT-specialists.

Conclusion

Robotics and biomedical engineering open new horizons for future medicine. And histology ensures automation of routine processes, accuracy and reproducibility of results, and also creates conditions for the transfer of digital tissue analysis.

The combination **of robotics, artificial intelligence and histology** forms a new direction — **intellectual morphology** , which is capable of radically changing the approach to diagnosis, research and training.

In this way, robotizirovannye tehnologii stanovyatsya neot'emlemoy chastyu sovremennoy meditsiny, formiruya prochnuyu vyaz medu ingeneriei, biologiey i klinicheskoi praktikoy.

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