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Tashkent International University of Education
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PROCEEDINGS

of the MMIT'25 International Conference

TA'LIMNING ZAMONAVIY USULLARI VA
INNOVATSION TEXNOLOGIYALAR

MODERN METHODS AND INNOVATION
TECHNOLOGIES IN EDUCATION

СОВРЕМЕННЫЕ МЕТОДЫ И
ИННОВАЦИОННЫЕ ТЕХНОЛОГИИ
В ОБРАЗОВАНИИ

29 May 2025, Tashkent, Uzbekistan

MAQOLALAR TO'PLAMI
СБОРНИК СТАТЕЙ



Tashkent International University of Education

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Modern methods and innovation technologies in education

**Современные методы и инновационные технологии в
образовании**

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AERODINAMIK TAHLILDA SUN'IIY INTELLEKT VA UCH KARRALI INTEGRALNING INTEGRATSIYASI

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Annotatsiya. Ushbu maqolada uch karrali integrallar asosida havo oqimini fazoviy tahlil qilish va bu jarayonda sun'iy intellekt vositalaridan samarali foydalanish imkoniyatlari o'rganiladi. Havo zichligi va tezlik maydonlarining uch o'lchamli fazodagi taqsimoti matematik modellashirish orqali ifodalanib, hisoblashlar sun'iy intellekt yordami bilan tezkor va vizual tarzda amalga oshiriladi. Maqola aerodinamik muammolarni hal etishda zamonaviy texnologiyalarning, xususan AI (Artificial intelligence) algoritmlarining, o'quv jarayoniga integratsiyasi orqali muhandislik ta'limining interaktiv va amaliy yondashuvini yoritadi. Tadqiqot natijalari fazoviy integral tahlilining avtomatlashtirilgan yechimlari orqali real tizimlarni modellashirishda yangi yondashuvlarni taklif etadi.

Kalit so'zlar: oqim, zichlik, vektor maydon, tezlik, massa, trayektoriya, aerodinamik qarshilik.

INTEGRATION OF ARTIFICIAL INTELLIGENCE AND TRIPLE INTEGRAL IN AERODYNAMIC ANALYSIS

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Abstract. This article examines the possibilities of spatial analysis of airflow based on triple integrals and the effective use of artificial intelligence tools in this process. The distribution of air density and velocity fields in three-dimensional space is expressed through mathematical modeling, and calculations are performed quickly and visually using artificial intelligence. The article highlights the interactive and practical approach of engineering education through the integration of modern technologies in solving aerodynamic problems, in particular AI (Artificial intelligence) algorithms, into the educational process. The research results propose new approaches to the modeling of real systems through automated solutions of spatial integral analysis.

Keywords: flow, density, vector field, velocity, mass, trajectory, aerodynamic resistance.

Kirish

Hozirgi muhandislik va aerodinamika sohalarida havo oqimi tahlili eng muhim yo'nalishlardan biridir. Samolyot aerodinamikasidan tortib, ventilyatsiya tizimlarigacha bo'lgan turli muammolarni hal qilishda fazoviy modellashirish va uch karrali integral muhim matematik vosita hisoblanadi. Bu turdagi kompleks modellarni o'rgatishda sun'iy intellekt (SI) va avtomatlashtirilgan hisoblash tizimlari muhandislik ta'limini sezilarli darajada takomillashtiradi. Havo oqimi uch o'lchamli fazoda o'zgaruvchi zichlik, tezlik va bosimga ega bo'lgan murakkab fizik hodisadir. Uni modellashirishda quyidagi uch karrali integral ishlatiladi:

$$\iiint_V \rho(x, y, z) \cdot \vec{v}(x, y, z) dV$$

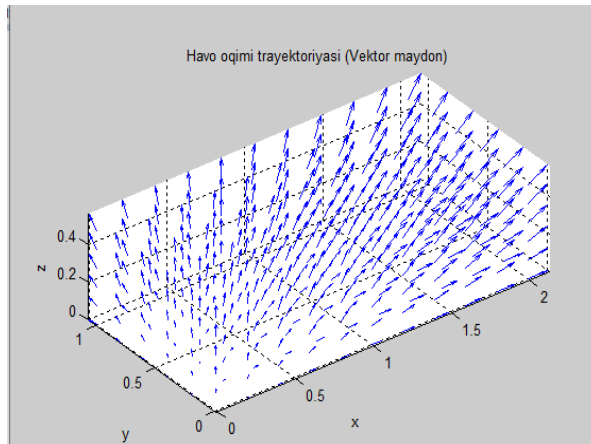
Bu yerda: $\rho(x, y, z)$: havo zichligi, $\vec{v}(x, y, z)$: havo oqimi tezligi vektor maydoni, V : o'rganilayotgan fazo hajmi. Bu integral orqali havo oqimining umumiy massasi yoki kinetik energiyasini aniqlanishi mumkin.

Havo oqimini modellashirish bo'yicha klassik ishlar orasida Anderson [1] tomonidan yozilgan "Fundamentals of Aerodynamics" asari asosiy manba hisoblanadi. Shu bilan birga, havo oqimi trayektoriyalarini raqamli yechimlar asosida tahlil qiluvchi zamonaviy tadqiqotlar, masalan, Versteeg va Malalasekera [2] tomonidan yozilgan "An Introduction to Computational Fluid Dynamics", fazoviy integral metodikalarini real muammolarga qo'llashda katta yutuqlarga erishgan. Bundan tashqari, AI texnologiyalarining muhandislik modellashirishiga integratsiyasi bo'yicha so'nggi yillarda chop etilgan maqolalar [3,4] mashina o'rganish algoritmlarining CFD modellariga tatbiqi orqali hisoblash tezligini sezilarli darajada oshirishga erishilganini ta'kidlaydi.

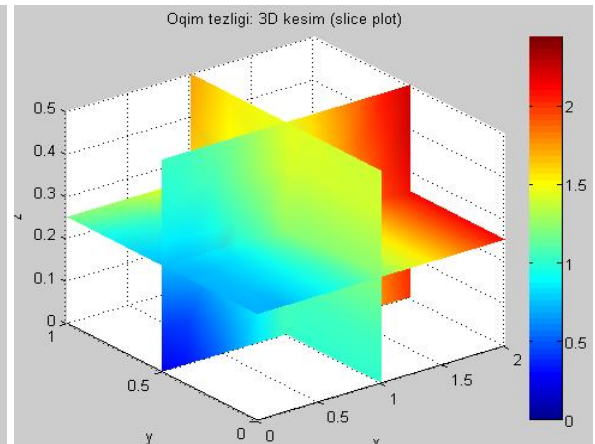
Sun'iy intellekt yordamida oqimni tahlil qilishda, fazoviy vizualizatsiya SI vositalari (masalan Wolfram Language yoki MATLAB) [5,6] yordamida uch karrali havo oqimi grafigi chiziladi. Bu grafiklar orqali havo oqimi trayektoriyasi va zichlikdagi o'zgarishlar vizual ko'rinishda namoyish etiladi. AI yordamida foydalanuvchi parametrlarni (zichlik, tezlik, hajm chegaralari) o'zgartirib turib, natijani real vaqtda ko'rishi mumkin:

```
clc;
clear;
% Havo zichligi
rho = 1.225;
% Integrallash uchun aniqlangan funksiya
f = @(x,y,z) rho .* (x + y.^2 + sin(pi.*z));
% Integral chegaralari: x ? [0, 2], y ? [0, 1], z ? [0, 0.5]
integral_value = triplequad(@(x,y,z) f(x,y,z), 0, 2, 0, 1, 0, 0.5);
fprintf('Integratsiya natijasi: %.4f\n', integral_value);
% Fazoni aniqlash
[x, y, z] = meshgrid(0:0.2:2, 0:0.2:1, 0:0.1:0.5);
% Har bir komponent uchun vektor maydoni
vx = x;
vy = y.^2;
vz = sin(pi .* z);
% 3D vektorli oqim maydonini chizish
figure;
quiver3(x, y, z, vx, vy, vz, 'b');
xlabel('x'); ylabel('y'); zlabel('z');
title('Havo oqimi trayektoriyasi (Vektor maydon)');
grid on;
axis equal;
view(3);
% Skalyar tezlik moduli
v_mag = sqrt(vx.^2 + vy.^2 + vz.^2);
% Yuzaki kesim - xz tekisligida y = 0.5
slice_x = squeeze(v_mag(:, round(end/2), :));
x_vals = 0:0.2:2;
z_vals = 0:0.1:0.5;
figure;
slice(x, y, z, v_mag, [1], [0.5], [0.25]); % x=1, y=0.5, z=0.25 kesimlar
xlabel('x'); ylabel('y'); zlabel('z');
```

```
title('Oqim tezligi: 3D kesim (slice plot)');
colorbar;
shading interp;
```



Rasm 1.



Rasm 2.

Rasm 1. har bir nuqtadagi oqim yoʻnalishi va intensivligini koʻrsatadi. Rasm 2. Yuqori tezlik zonalari (qizil) – bu yerda havo kuchliroq harakat qilmoqda. Bunday joylar aerodinamika dizaynida muhim: masalan, qanot yoki ventilyator yaqinidagi oqimlar. Past tezlik zonalari (koʻk) – bu yerda oqim sust yoki turgʻun. Bu turgʻunlik issiqlik yoki chang yigʻilishi uchun muhim signal boʻlishi mumkin. Oqim simmetriyasi yoki notekisligi – grafik orqali oqim bir tekis taqsimlanganmi yoki yoʻqligini aniqlash mumkin. Bu, ayniqsa, ventilyatsiya tizimlarini loyihalashda foydalidir.

Sunʼiy intellekt yordamida mashina oʻrganish algoritmlari orqali havo oqimi trayektoriyasi bashorat qilinadi — bu berilgan geometriya, chegaraviy shartlar va fizik parametrlar asosida havo zarrachalarining fazodagi harakat yoʻlini oldindan hisoblash demakdir. Odatda, bu jarayon Navye-Stokes tenglamalari yoki CFD (Computational Fluid Dynamics) modellar orqali hal qilinadi. Lekin ular resurs talabchan va sekin boʻlishi mumkin. Shu sababli, AI — ayniqsa, mashina oʻrganish (machine learning, ML) — bu modellashtirishni tezlashtirish va bashoratlash uchun ishlatiladi. Bu, ayniqsa, murakkab geometriyalı tunnel va qanotlarda oqimni oldindan koʻrish uchun foydalidir. Muhandislikda amaliy qoʻllanilishi esa:

Aviatsiya: qanot atrofidagi havo oqimini tahlil qilish;

Avtomobilsozlik: aerodinamik qarshilikni kamaytirish;

Binolar ventilyatsiyasi: havoning ichki oqimini optimallashtirish;

Sanoat chang yutish tizimlari: havo oqimi orqali zararli moddalarning yoʻnalishini aniqlashda foydalanish mumkin.

Ma'lumotlarni tayyorlash

```
n = 1000;
```

```
x = 2 * rand(n,1);
```

```
y = rand(n,1);
```

```
z = 0.5 * rand(n,1);
```

```
vx = x;
```

```
vy = y.^2;
```

```
vz = sin(pi * z);
```

```
X = [ones(n,1), x, y, z];
```

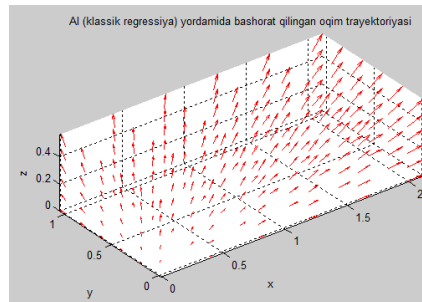
Koeffitsientlarni topish (klassik regressiya)

```
beta_vx = (X' * X) \ (X' * vx);
```

```

beta_vy = (X' * X) \ (X' * vy);
beta_vz = (X' * X) \ (X' * vz);
Yangi nuqtalar uchun bashorat
[xq, yq, zq] = meshgrid(0:0.4:2, 0:0.2:1, 0:0.1:0.5);
Xq = [ones(numel(xq),1), xq(:), yq(:), zq(:)];
vx_pred = Xq * beta_vx;
vy_pred = Xq * beta_vy;
vz_pred = Xq * beta_vz;
Trayektoriya grafikasi
figure;
quiver3(Xq(:,2), Xq(:,3), Xq(:,4), vx_pred, vy_pred, vz_pred, 'r');
xlabel('x'); ylabel('y'); zlabel('z');
title('AI (klassik regressiya) yordamida bashorat qilingan oqim trayektoriyasi');
grid on;
axis equal;
view(3);

```



Rasm 3

Rasm 3. Grafikda har bir nuqtadagi bashorat qilingan tezlik vektori uch o'lchamli fazoda ko'rsatilgan. Bu trayektoriyalar sun'iy ma'lumotlar asosida mashina o'rganish modeli orqali o'rganilgan va yangi nuqtalarda bashorat qilingan. Vektorlar zarrachalarning harakat yo'nalishi va kuchini anglatadi. Ushbu model havo oqimini tez va resurssiz modellashtirish uchun ishlatilishi mumkin. Klassik regressiyaga asoslangan sun'iy intellekt modeli tomonidan bashorat qilingan oqim trayektoriyasi. Har bir vektor oqim yo'nalishini ifodalaydi.

Xulosa

Uch karrali integrallar yordamida havo oqimini modellashtirish muhandislikda fundamental ahamiyatga ega. Sun'iy intellekt esa ushbu murakkab matematik modellarni soddalashtirish, tezlashtirish va vizual ko'rinishga keltirishda katta yordam beradi. Bu yondashuv muhandislik ta'limini yanada interaktiv va samarali qiladi.

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An abstract graphic featuring a complex network of interconnected nodes and lines, resembling a molecular structure or a digital network, set against a dark blue background. The nodes are represented by circles of varying sizes, and the lines are thin, light blue, creating a web-like pattern that fills the upper two-thirds of the page.

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