RECENT RESEARCH IN COMPUTATIONAL FLUID MECHANICS

Dr. Nor Azwadi bin Che Sidik
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1. To inform current research topics in the field of Computational Fluid Mechanics

2. To promote research topics for Undergraduate Projects (UGP), Master Project/Master Research or PhD research
The **systematic investigation** into and study of materials and sources in order **to establish facts** and **reach new conclusions**.
1 Graduation requirement
2 Platform to demonstrate student’s creativity and apply knowledge
3 Contribute to new knowledge
3 To disseminate knowledge
4 To get money/claim (publication incentives)
5 Etc
When considering topics for a workable research problem, ask the following questions:

• Do I possess the skills necessary to complete this study?
• Do I have access to the tools, lab, and equipment to complete this project?
• Do I have the time and money necessary to complete this project?
• Do I have the resources necessary to obtain sufficient data?
• Do I have access to a professional in that field who will be willing and able to advise me in the research process?
Choose a research topic that interests you. Then..........
*Find a study that has already been done and replicate it using new definitions of some of the variables in the study (UG).

-or-

*Find a study that has already been done and replicate it using additional moderator or control variables (UG/PG(t))

-or-

*Find an existing study and develop a different way to test the hypothesis (PG(t/r))

-or-
*Follow an author’s suggestions for further research needed - usually found at the end of an article (PG(r))

-or-

*Contact the author of an interesting study using the internet for ideas for further study (PG(r))

-or-

*Choose a problem, analyze it, and invent a completely new study (Ph.D)
CRITERIA FOR CHOOSING A SUPERVISOR

• Freedom to work (FW) - The supervisor is open to ideas and is flexible about adopting alternative approaches.
• Time conscious (TC) - The supervisor is conscious about time taken for completion and is generally willing to work towards it.
• Job prospect (JP) - The supervisor’s ability to help the candidate in obtaining a suitable job after completion of dissertation.
• Convergence of interest (CI) - The matching of interest of the student and the supervisor.
• Reputation/Subject knowledge/Publications (RP) - The reputation of the supervisor in his or her field.

INSPIRING CREATIVE AND INNOVATIVE MINDS
CRITERIA FOR CHOOSING A SUPERVISOR

- Personal relationship with the professor (PR) - Cordial and understanding relationship with the supervisor
- Social networks (SN) - The supervisor’s social network and relationship with other professors in the institute and outside
- Number of thesis guided (TG) - Number of thesis guided by the supervisor, the more the better
- Commitment and involvement (IN) - Supervisor’s enthusiasm in guiding the thesis, emotional investment
1. Solution to the lattice Boltzmann equation
2. Solution to the Navier-Stokes Equation
3. Application of Numerical Software
1. Solution to the lattice Boltzmann equation

Lattice Boltzmann equation – Evolution equation of particle distribution function (translation and collision).

\[
f_i(x + \varepsilon_i \Delta t, t + \Delta t) = f_i(x, t) - \frac{1}{\tau_f} [f_i(x, t) - f_i^{eq}(x, t)]
\]
Translation

\[ f_i(\ddot{x} + \ddot{e}_i \Delta t, t + \Delta t) = f_i(\ddot{x}, t) \]

Collision

\[ f_i(\ddot{x} + \ddot{e}_i \Delta t, t + \Delta t) = -\frac{1}{\tau_f} [f_i(\ddot{x}, t) - f_{i}^{eq}(\ddot{x}, t)] \]

Equilibrium function

\[ f_{i}^{eq} = \omega_i \rho \left[ 1 + \frac{3\ddot{e}_i \cdot \ddot{u}}{C^2} + \frac{9(\ddot{e}_i \cdot \ddot{u})^2}{2C^4} - \frac{3\ddot{u} \cdot \ddot{u}}{2C^2} \right] \]
Fluid flow parameters

- Density
- Velocity

Skill required
MATLAB or Fortran
ex: translation

```matlab
%%%% streaming %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
for i=1:9
f(i,:,:)=circshift(f(i,:,:),[0,cx(i),cy(i)]);
end
```

Flow density: \( \rho = \sum_i f_i \)
Momentum: \( \rho u_j = \sum_i f_i c_{ij} \)
ex: collision

```matlab
for i=1:lx
    for j=1:ly
        cul=u(i,j)^2+v(i,j)^2;
    end
    for k=1:9
        cu2=u(i,j)*cx(k) + v(i,j)*cy(k);
        fEq(k,i,j)=rho(i,j)*Weight(k)*(1+3*cu2+4.5*cu2^2-1.5*cul);
        f(k,i,j)=omegaF*fEq(k,i,j)+(1-omegaF)*f(k,i,j);
    end
end
```

ex: density and velocity

```matlab
rho = reshape(sum(f),lx,ly);
u(:,:) = reshape(cx * reshape(f,9,lx*ly),lx,ly)./rho;
v(:,:) = reshape(cy * reshape(f,9,lx*ly),lx,ly)./rho;
```

INSPIRING CREATIVE AND INNOVATIVE MINDS
Leila Jahanshaloo, Emad Kermani and Nor Azwadi Che Sidik, “A review on application of lattice Boltzmann method for turbulent flow simulation”, *Numerical Heat Transfer, Part A Application*, Accepted for publication. (IF 2.492).
Lattice Boltzmann method for turbulent flow in rotating channel – Basha M., Ph.D

Lattice Boltzmann method for particulate flow, Leila J., Ph.D., Aman AK., Ph.D., Akmal H., Master

http://www.youtube.com/watch?v=aFRI_6TByEE

Few papers submitted to high impact journals
Lattice Boltzmann method for nanofluid

Some improvements of the lattice Boltzmann method

Shervin Sharafatmandjour, Nor Azwadi Che Sidik, Sabetghadam, “A least squared based immersed boundary approach for the complex boundaries in lattice Boltzmann Method”, *Numerical Heat Transfer Part B- Fundamental*, Accepted for publication. (IF 2.054)


Simulation of contaminant removal using Lattice Boltzmann Method
2. Solution to the Navier-Stokes equation

Navier-Stokes equation – governing equation for fluid flow

\[
\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + w \frac{\partial u}{\partial z} = -\frac{1}{\rho} \frac{\partial p}{\partial x} + \frac{\mu}{\rho} \left( \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} \right) + \frac{f}{\text{body forces}}
\]
Discretisation using finite different method
Required skill: Matlab/fortran

```matlab
for i = 2: imm1
    for j = 2: jmm1
        %velocity component
        u(i,j) = (p(i,j+1)-p(i,j-1))/(2*dy);
        v(i,j) = -(p(i+1,j)-p(i-1,j))/(2*dx);

        %stream function equation
        p(i,j) = (o(i,j)*(dy^2)+(dy^2)*(p(i+1,j)+p(i-1,j))/(dx^2) + (p(i,j+1)+p(i,j-1))/...)
            (2*(dx^2)/(dy^2) +2);
    end
end
```
High order solution scheme of Navier-Stokes equation (CIP), Mehran, Master

Mehran Salehi, Nor Azwadi Che Sidik, “Prediction of flow characteristics in stenotic artery using CIP Scheme” International Journal of Materials and Mechanical Engineering, 7, 101-106
Nor Azwadi Che Sidik, Mehran Salehi, “Eulerian-Lagrangian numerical scheme for contaminant removal from different cavity shapes”, *The Arabian Journal for Science and Engineering*, Accepted for publication. (IF 0.243)
3. Application of numerical software

FLUENT software
Required skill
Familiar with the software
Contaminant flow in urban street canyon, Afiq, Ph.D
Contaminant flow in urban street canyon

Afiq Witri, Nor Azwadi Che Sidik, Khaled Saqr and Salim Mohamad Salim, “A review on the flow structure and pollutant dispersion in urban street canyon” SIMULATION, Accepted for publication with minor correction. (IF 0.793)
Fish Fin morphology
### Nor Azwadi, C. S.

**Personal**

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### Research

**Documents**

111

**References**

1009

**Citations**

209 total citations by 139 documents

**h Index**

9

**Co-authors**

94

**Web search**

70

**Subject area**

Engineering, Physics, and Astronomy, Computer Science

### History

**Publication range**

2006-Present

**Source history**

Applied Mechanics and Materials

2010 2nd International Conference on Computer Engineering and Applications, ICCEA 2010

Computers and Fluids

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<th>Subject Areas</th>
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6. Yenman, J.M. 39 documents
7. Sidik, N.A.C. 38 documents
8. Tsutahara, M. 37 documents
9. Chen, H. 36 documents
10. Derksen, J.J. 35 documents

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