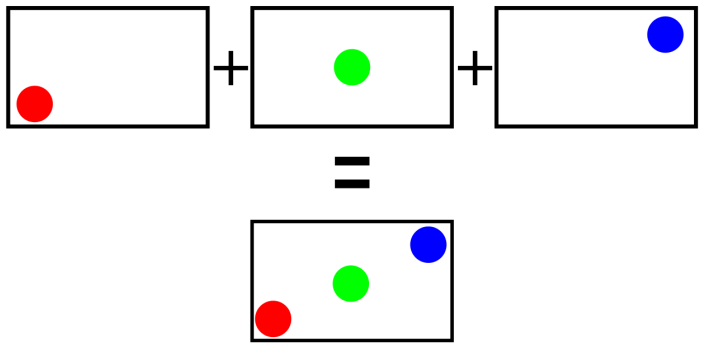
Table of contents

Effects of cross contamination in colour PTV

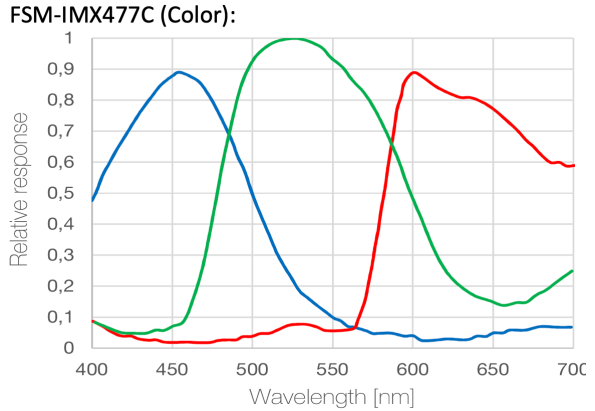
Keywords: Colour PIV, Iterative pressure reconstruction

Project proposal

- Track tracer particles in a fluid flow using red, green and blue lighting to reconstruct their path over short timescales
- Because red LEDs don’t only activate the red channel, this colour spillage will need to be corrected in software
- Particle tracking code will be written to evaluate the usefulness of the previous steps



Visual aid for what synthetic images will look like, own work



Response to different wavelengths for a typical image sensor, Framos 2019

Background

- 3D Lagrangian Particle Tracking in Fluid Mechanics (Schröder & Schanz, 2022)
  - Overview of the history of particle tracking

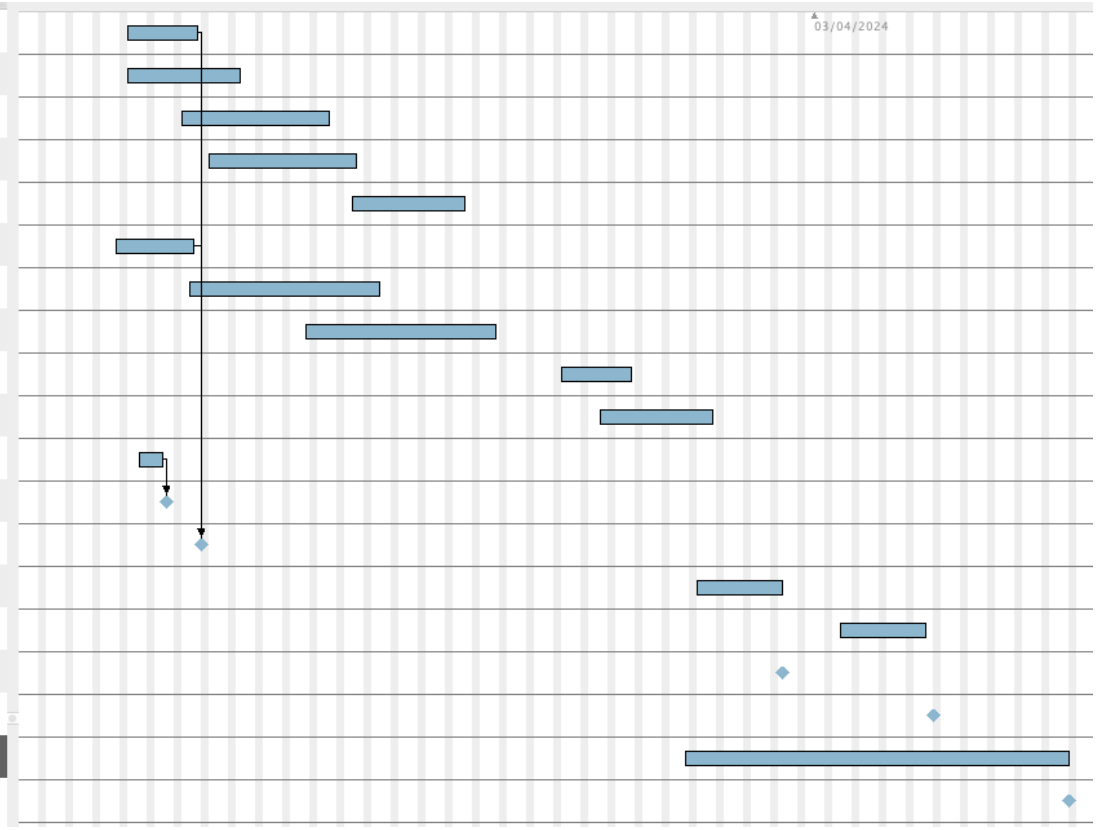
- A triple-exposure color PIV technique for pressure reconstruction (Wang et. Al., 2017)
  - Using 3 colours to gain more temporal information with cheaper equipment
- Most methods have used high-end optical systems to acquire the data, although some work has been done to lower the barrier to entry. This will be a continuation of those efforts

Aims and Objectives

- Find the effects of colour contamination in colour PTV
  - Add the effects of colour spill into existing Gigatrack codebase
  - Quantify how much this affects the accuracy of synthetic particles
- Test the code on experimental data
  - Gather data of real flows with real hardware
  - Test the data using the processing pipeline

Rough timeline

Literature review	09/10/2023	26/10/2023
Review code	09/10/2023	06/11/2023
Extend code to add colour spill	23/10/2023	29/11/2023
Work on cleaning up spill	30/10/2023	06/12/2023
Finish up last bits of code	06/12/2023	03/01/2024
Write interim review	06/10/2023	25/10/2023
Particle tracking code	25/10/2023	12/12/2023
Document code changes	24/11/2023	11/01/2024
Gather experimental data	29/01/2024	15/02/2024
Test experimental data	08/02/2024	07/03/2024
Write PPP	12/10/2023	17/10/2023
Project plan presentation	18/10/2023	18/10/2023
Interim review	27/10/2023	27/10/2023
Finalise draft report	04/03/2024	25/03/2024
refine draft report	10/04/2024	01/05/2024
draft report	25/03/2024	25/03/2024
Final report	03/05/2024	03/05/2024
poster	01/03/2024	07/06/2024
Poster presentation	07/06/2024	07/06/2024



Training needs

- Lab induction – Later today
- Codebase review – Tomorrow
- General MATLAB experience - Ongoing

Training needs:

Lab induction into Experimental Fluids Labs in Building 185
DSE usage training
Gigatrack training
Academic writing

The labs will be important for gathering experimental data, so the induction is important in the process of writing a risk assessment for my work in these laboratories and understanding any specific procedures that will need to be followed.
To complete this induction, Sam Harper was contacted and an induction was completed.

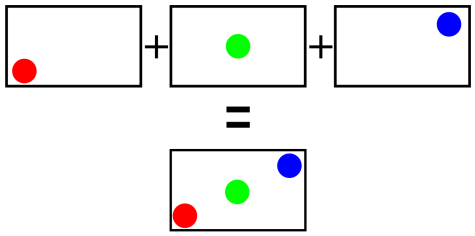
A large part of the project will be spend working at a computer, for writing additional code as well as writing the final project. For this reason, training should be undertaken to ensure that this work is conducted in a safe manner.
To do this, DSE training on Blackboard has been completed.

As I will be working with an existing codebase, I will have to understand how to use the code to add to it. To do this, a meeting will be planned with my supervisor to ensure that I understand the important functionality.
The meeting was completed.

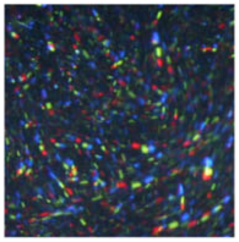
This will be the largest body of work that I have written, and I need to ensure that I can communicate what I have done effectively and clearly. To aid me in developing this skill, I will work through the English for Academic Purposes toolkit on Blackboard.

Fluid dynamics is inherently complicated, as are the equations that govern it. One way to reduce this complexity when running tests is by removing the equations and their intricacies. A simple, low-fidelity way to do this is by using smoke in a wind tunnel, but this can only give relatively low-resolution detail about how the fluid is moving. To answer more complex questions, more advanced methods have been developed. The one that I will be working on is known as Particle Image Velocimetry, and it works by putting small particles in the flow, and then following where these particles go.

To identify a particle at two different points in time, the positions need to be fairly close together. To do this, high-speed cameras and bright laser systems have historically been used. These are obviously very expensive, limiting the use of these systems to institutions with enough funding . Additionally, more volume of fluid needs more cameras, so measuring large volumes can either cost a lot of money, or need trade offs. Work has been done to bring down the cost of these methods to allow more researchers to use it in the past, and my project will be a continuation of this. I will be using a camera that is similar to one in your phone, and some bright LEDs to bring down the cost. The light will be flashed different colours at different times, resulting in an image like the ones below.

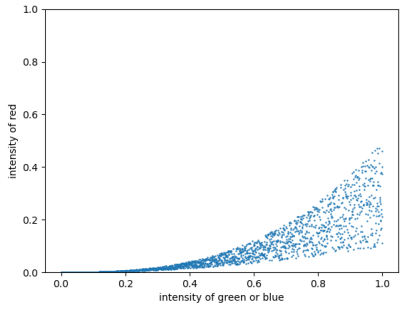


An illustration of what the tracking may look like



A real image using a similar technique from existing work (Wang & Wang, 2017)

The issue I will be dealing with in my project is that green light from the cameras doesn't only activate the green pixel, the red and blue pixels also detect some light, and the same is true for all of the other combinations of colours. This could result in the software thinking that there are more particles than really exist, leading to issues tracking the fluid flow. The amount that each light affects each other channel isn't linear, and the diagram to the left represents this.



A representation of how the colour channels affect each other. This isn't real data, but it is indicative of

My project will involve getting data from real cameras and LEDs and seeing what the curve looks like. Then, I will simulate this effect in software.

Once the software is working well, I will gather experimental data from in a lab and test my software against that data, it is pointless to have code that works well for made up data but breaks when it deals with the imperfections of the real world.

Date: March 2022 / Version: 1

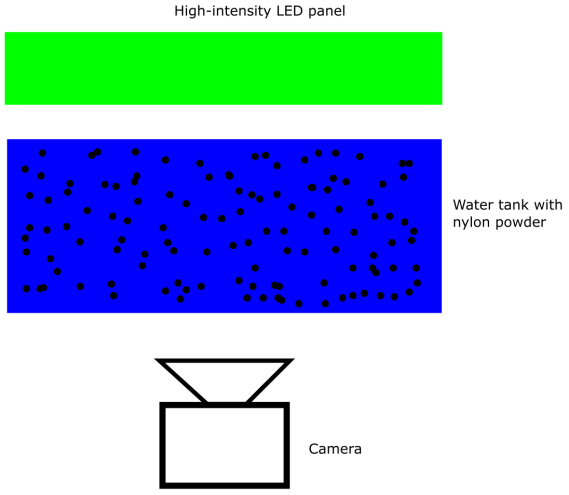
School of Engineering	Method Statement

Title
Computational and experimental work on Individual Project

Location of Activity	**Date**
B185 Labs 1 and 3	23/10/2023
Assessor Natalie Ko-Ferrigno	**Contact Details** *Tel: 07734246427* *Email: mkf1g21@soton.ac.uk*
Supervisor John Lawson	**Contact Details** *Tel:* *Email:*

Introduction / Overview.
This project aims to characterise the colour spill for a specific optical system. This will be achieved primarily through writing code to simulate it, but there will also be experimental testing of the code with data that I gather from Lab 1 or 3. During testing, an array of cameras and LED panels will be set up, and air will be blown through containing tracer particles.

Description of Task and how it will be carried out.
The first task is to figure out the transfer function that governs the colour spill. This will be done by adding features to simulate colour spill into the Gigatrack codebase during synthetic image generation, and then writing code to correct for this effect. During this phase, some quantities like the number of ghost particles this adds can be estimated.
The second phase will be more centred around experimental work, and this is the phase that I will need access to the labs. In this phase, a MP-PTV setup will be used to generate experimental data, and the portion of Gigatrack that tracks particles will be used. This setup includes having nylon powder in flowing water to generate shadows for a nearby camera to pick up, as shown below.



The camera will be near the water, as will the high-intensity LED panels.

Control Measures including training, PPE
Most important is an induction into the lab. This included who to contact in case of emergency and relevant information regarding safety in the lab. In addition to this, there will never be a single person working in the lab. The cameras will be controlled by Raspberry Pi computers. To minimise the risk of fire, the power supplies will be PAT tested. Because of the nature of the work, electronics have to be close to the water tank. Where this does not affect optical quality, shields will be made to minimise the chance of water hitting electronic components. This is especially important for the LED panels, as these are higher power than the Raspberry Pis. In addition to

this, there will be a label on the water tank saying not to hit, to minimise the risk of water splashing out and hitting the electronics. This is also important because spilled water can increase the risk of slips, trips and falls. To minimise this risk, any spills will be cleaned up promptly. Nylon powder can irritate the skin, eyes and lungs, but it doesn't pose any major health hazards. To minimise the risk of harm, the materials safety data sheet will be on hand so that prescribed procedures can be followed.

Emergency Arrangements

If an emergency occurs such as a fire or life-threatening injury or event, the labs have a landline that
can be used to reach for help using the emergency service number 3311/023 8059 3311.
In case of a fire, each lab has signs leading to the nearest exit leading to the evacuation point in the
centre of the Boldrewood campus. The building has a fire alarm system which is tested weekly.
There is first aid information for the trained staff first aiders in the lab and if emergency services are
needed then call 999.

Additional persons involved in activity

N/A

Risk Assessment

Risk Assessment for the activity of	**Computational and experimental work on Individual Project**	**Date**	**23/10/2023**
Unit/Faculty/Directorate	**Engineering**	**Assessor**	**Natalie Ko-Ferrigno**
Line Manager/Supervisor	***John Lawson***	**Signed off**	

PART A

(1) Risk identification			**(2) Risk assessment**				**(3) Risk management**			
Hazard	**Potential Consequences**	**Who might be harmed** **(user; those nearby; those in the vicinity; members of the public)**	**Inherent**			**Control measures (use the risk hierarchy)**	**Residual**			**Further controls (use the risk hierarchy)**
			Likelihood	**Impact**	**Score**		**Likelihood**	**Impact**	**Score**	
Cables presenting trip hazard	Falling resulting injury, head injury from large items in the lab	Anyone in the lab	**3**	**2**	**6**	**Ensure cables are at waist height or covered. Ensure they have high-visibility markings.**	**2**	**1**	**2**	Minimise use of trailing cables where possible
Display Screen Equipment Usage	Eye strain, repetitive strain injuries, back/shoulder/headache	Computer user	**4**	**3**	**12**	**Complete DSE training Set up equipment properly Take regular breaks**	**1**	**2**	**2**	
Slips, trips and falls from water on floor	Wrist injuries, bruising	Anyone on the lab	**3**	**2**	**6**	**Ensure any spillages are cleaned up promptly**	**1**	**2**	**2**	

PART A											
(1) Risk identification			**(2) Risk assessment**				**(3) Risk management**				
Hazard	**Potential Consequences**	**Who might be harmed** **(user; those nearby; those in the vicinity; members of the public)**	**Inherent**			**Control measures (use the risk hierarchy)**	**Residual**			**Further controls (use the risk hierarchy)**
			Likelihood	**Impact**	**Score**		**Likelihood**	**Impact**	**Score**	
Electronics near water	Shock Fire	Anyone in the lab	**2**	**3**	**6**	**Use a physical barrier between electronics and water** **Signage to indicate the hazard**	**1**	**3**	**3**	
Nylon powder	Eye and skin irritation	Anyone in the lab	**3**	**2**	**6**	**Only move the powder in a well-ventilated area.** **Ensure access to MSDS**	**2**	**1**	**4**	

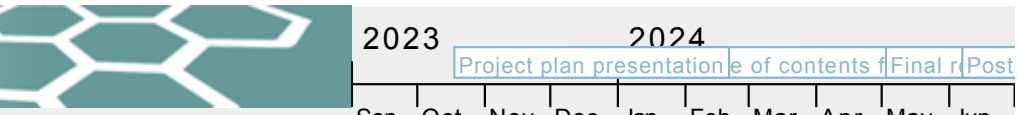
PART B – Action Plan

Risk Assessment Action Plan

Part no.	Action to be taken, incl. Cost	By whom	Target date	Review date	Outcome at review date
	Move large items out of walkways	Technician	29 Jan 2024		
	Undergo training for setting up DSE on Blackboard	Natalie Ko-Ferrigno	22 Oct 2023	29 Oct 2023	Completed and understood, 100% on the short test
	Ensure a mop is nearby and known so the spill can be cleaned	Natalie Ko-Ferrigno	29 Jan 2024		
	Manufacture enclosures/shields for electronics	Natalie Ko-Ferrigno	05 Feb 2024		

Responsible manager's signature: Print name: Date:	Responsible manager's signature: Print name: Date

Gantt Chart



Name	Begin date	End date
Literature review	09/10/2023	19/04/2024
Review code	09/10/2023	06/11/2023
Extend code to add colour spill	23/10/2023	29/11/2023
Work on cleaning up spill	30/10/2023	06/12/2023
Finish up last bits of code	06/12/2023	03/01/2024
analysis of real colour spill	06/11/2023	04/12/2023
Write interim review	06/10/2023	25/10/2023
Particle tracking code	25/10/2023	12/12/2023
Document code changes	24/11/2023	11/01/2024
Gather experimental data	29/01/2024	06/03/2024
Test experimental data	08/02/2024	07/03/2024
Write PPP	12/10/2023	17/10/2023
Project plan presentation	18/10/2023	18/10/2023
Interim review	08/12/2023	08/12/2023
Finalise draft report	04/03/2024	25/03/2024
table of contents for draft report	01/02/2024	01/02/2024
refine draft report	10/04/2024	01/05/2024
draft report	25/03/2024	25/03/2024
Final report	03/05/2024	03/05/2024
poster	01/03/2024	07/06/2024
Poster presentation	07/06/2024	07/06/2024

Subject: RE: Tuesday's meeting notes
Date: Thursday, 19 October 2023 at 15:38:34 British Summer Time
From: John Lawson
To: Natalie Ko-Ferrigno (mkf1g21)
Attachments: image002.png, image003.png

Hi Natalie,

Following up from our meeting today, I have

- Made you an account on my NAS (see separate email)
- Placed data from the testing of Raspi Cameras / GSVitec LED arrays in your home folder on the NAS
- Updated the gigatrack repository with latest changes
- Placed point cloud data from JHU turbulence database in your home folder, so you can begin to create some synthetic images with gigatrack

All the best,
John

From: Natalie Ko-Ferrigno (mkf1g21) <mkf1g21@soton.ac.uk>
Sent: 19 October 2023 10:26
To: John Lawson <J.M.Lawson@soton.ac.uk>
Subject: Tuesday's meeting notes

meeting 17.10.23

#IP

prep work

"How many ghost particles are likely to be made from cross-contamination in TE-PTV?"
what should i include in the presentation

in meeting

know your audience
melike has mechanical engineering degree
only really need one pitch

working title - keywords - background - aims and objectives - gantt chart - training needs analysis

workshop inductions, lab inductions

who to talk to about matlab

probably just go online
linkedin
just the same way as everything else with coding

how to run the matlab code

will have to talk about it

one function to set a bunch of particles and make images

two function to analyse the images, low density and high density
some stuff for velocity distributions etc
probably write my own analysis

training need: the codebase but do some more matlab first
in person going over the code with supervisor

title

proposed one too long

find a thing for the cross conton
"effects of cross contamination in colour ptv"
aims can then be stuff like "effecets on the velocity measurement stuff"
objectives "evauluate the ..."
aims "figure out the effects of real expeimental hardware"

reality informed" simulation of the setup

objectives

add effects ot PTV code to simulate PTV cross contamination

experimental component

get some cameras set up in lab
generate particle images
see how well demultiplexing works

get camera geometric calibration working

have to do on a per colour thing for chromatic abberation
apply the correction to low-density particle stuff, try and reconstruct things

shake the box

find what the particles will look like when its not in the focal plane
maybe just keep it to the low density stuff

overall structure

spend time getting code right to simulate everything
use experimental data as more of a test of what i've done

send notes as a screenshot

for next time

start on the interim project review
layman's summary
gantt chart
method statements

Subject: Meeting notes
Date: Tuesday, 31 October 2023 at 10:33:01 Greenwich Mean Time
From: Natalie Ko-Ferrigno (mkf1g21)
To: John Lawson
Attachments: image001.png

I've attached the meeting notes from today

meeting 31.10.23

#IP

prep

what do i actually submit, is it just one big word doc?
companies?

in meeting

submit everything as one pdf

context of what its done and what it will solve is good

big tank of water near electronics, thats a risk. spills and electrical hazard
chemicals and other stuff to be aware of, probably dont mention it in the risk assessment

tracer particles in a tank of water. tracers are a powder, dont inhale. used for powder painting, nylon powder

currently using shadows, maybe adapt the code to reflect that
slips, trips and falls - tape down cables and have them neatly
mop up spills
separate electronics from spills

training needs is good

milestone is basically "have i planned it" and to clear out misconceptions. Focus on the project now

internships

tsi - american
lavision - mostly in germany
dantech dynamics

john is running an internship, there are also other unis tho
andreas schöder at DLR is a good person
ICL has some partical tracking stuff
UCL, too Christoph Brücker
jobs.ac.uk

might be challenging to get a year in industry

for next time

lit review
get to grips with gigatrack