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EPSRC Fellowship Peer Review

EPSRC Reference: EP/S00503X/1

Document Status: With Council

EPSRC Fellowship - Early Career

Applicant Details

Applicant	Dr Ohad Kammar	Organisation	University of Oxford

Title of Research Project

Type refinement through algebraic effects

Review Information

Response Due Date	16/05/2018	Reviewer Reference:	204618569

Quality

Primary criterion. Please comment on the degree of research excellence of the proposal, making reference to:
(1) The novelty, relationship to the context, and timeliness;
(2) The ambition, adventure, and transformative aspects identified;
(3) The appropriateness of the proposed methodology.
(For multi-disciplinary proposals please state which aspects of the proposal you feel qualified to assess)

We need to be able to reason mathematically about software in order to gain assurance of systems that deploy it. However, our ability to do this lags behind the features of programming languages and demands of systems themselves. The semantic frameworks that are needed seem to be constantly challenged by advances such as autonomy, and machine learning. This proposal aims to create building blocks from which such frameworks may be more readily constructed than at present.

(1) Novelty: The proposal aims to develop a theory of refinement types and to use this to verify Bayesian systems with the ultimate goal of assuring `intelligent' systems. Although I am not steeped in the area, I do believe this to be a novel approach, and the Case for Support (CfS) makes a good case. Its potential as an industry-deployable semantic framework depends on factors outside the scope of the project as presented, but the connection to industry through InfiniteMonkeys.ai does give some confidence that practical utility may guide the work to an extent.

Relationship to Context: There are many approaches to developing frameworks for reasoning about software, as the proposal notes. Advances in programming language semantics such as those envisaged in this project typically find their way into verification support tools and into the designs of specialist languages.

Timeliness: The proposal addresses timeliness quite well. As the CfS notes (pg 6), the work proposed required developments to bring us within reach of verification of `intelligent' systems. Now that's been done. Further, we need to do

this work now because of the increasing demands for computing systems that learn and act with unprecedented autonomy, implying the need for well-founded verification tools.

(2) Ambition: The project is ambitious in scope in that it seeks to influence the research agenda in programming language semantics as well as ultimately making progress towards the verification of particularly challenging classes of product. The programme (CfS pgs 7-8) testifies to the fact that there is some adventure here in that (understandably) the risk analysis tends to thin out in the later work packages. The proposal did not seem to me to offer a discussion of the potential for transforming the foundations and practice of verification for modern and intelligent systems

(3) The methodology is typical for advances in programming language semantics. The work is largely theoretical in the sense that there is little reliance on experimental observation. The integration of the resulting theories in F* and LiquidHaskell is quite likely to bring to the fore any issues around the tractability or pragmatics of program verification in this framework, and so I am confident that the project sets up a basis for evaluating the utility of the formal results.

Importance

Secondary major criterion. Comment on the national importance of the research. How it:
(1) Contributes to/helps maintain the health of other disciplines, contributes to addressing key UK societal challenges and/or contributes to future UK economic success and development of emerging industry(s);
(2) Meets national needs by establishing/maintaining a unique world leading activity;
(3) Complements other UK research funded in the area, including any relationship to the EPSRC portfolio.

The discussion of national importance in the CfS is cursory. However, the proposal builds on an area of undoubted UK research leadership in semantics and verification, and will likely strengthen it still further. It will fit well with and help to maintain UK-based expertise in formal methods, software and systems engineering. It certainly complements the broad range of research in formal methods in which the UK plays a preeminent role internationally.

On the other hand, the discussion of national importance in the CfS did not go far beyond the academic community to look at the potential for better, faster or cheaper verification of critical systems in some of the machine learning and AI application areas (such as autonomous vehicles) identified elsewhere in the proposal. If the fellowship is to advocate successfully for research in this field, an awareness of the potential benefit chain should be demonstrated.

Impact

Secondary criterion. Please comment on the pathway to impact identified for this work, particularly:
(1) How complete and realistic are the impacts identified for this work;
(2) The effectiveness of the activities identified to help realise these impacts, including the resources requested for this purpose;
(3) The relevance and appropriateness of any beneficiaries or collaborators.

Impacts are defined in the proforma and the Pathways to Impact (PtI).

(1) The proforma identifies 13 areas of potential impact, and I believe that these are reasonably comprehensive. In several of the 13 areas (notably International Development, Quality of Life, Economy, Wealth Creation, and Inward Investment), I could not see proposals for substantive activities that address these within the fellowship. The clear focus in the PtI is on knowledge outcomes and the trained individuals (RAs and interns, which I believe the CfS refers to as `the next two generations of researchers in programming language theory').

The PtI does propose realistic forms of impact within the limited areas addressed. Its less clear on the eventual business impact of enhanced semantic foundations via improved verification technology: there seems to be a lot of reliance on just one business (InfiniteMonkeys.ai) to provide the industry insights that might guide, develop, or even redirect the research. I

find this reliance on a single industrial contact to be a concern, especially as it is relied on to a great extent for the full five years of the proposed fellowship. The collaborators could help more proactively here, and I would rather have seen Microsoft as project partners alongside InfiniteMonkeys.ai.

(2) The main impact measure discussed is an exciting and original Internship Programme that I feel sure will attract outstanding candidates, and give them a rare combination of experience working across the whole technology stack from semantic foundations to industry applications. The proposal also refers to the applicant's wish to develop and promote a research and development agenda relevant to the field, though again this is focussed primarily on the scientific research community, and there is no concrete detail on how the relevant community will be engaged in the earlier stages of the project (other than through normal scientific workshops).

(3) The main collaborator is InfiniteMonkeys.ai, and they are entirely relevant and appropriate. I have, however, indicated above that I feel there is too much reliance on a single partner here, for both contribution to impact and scientific guidance. Is there a risk that the project may be over-influenced by one partner's needs, given that there is little consideration in the PtI of industry interaction beyond InfinteMonkeys.ai and Microsoft?

Ability to Deliver

Secondary criterion. Please comment on the applicant's ability to deliver the proposed project, making reference to:
(1) Appropriateness of the track record of the applicant(s);
(2) Balance of skills of the project team, including academic partners.

On the basis of the track record, I have no doubt at all about the competence of the applicant to pursue the programme of work outlined. He has been a contributor of high quality results in an active and competitive field of work, and this is clearly the correct basis for the proposed research.

I felt less confident about the applicant's experience in supervising and managing the work of others. The CfS refers to experience in supervising two MPhils (CfS, pg 2), but does not appear to give an account of any other project leadership (PhD supervision, management of RAs, etc.) I appreciate that this is an early career fellowship, but the proposer is likely to end up managing the work of two RAs, some interns and the DPhil student provided by his college (see letter of support from Balliol). The management of a research team is not a trivial task, and surely part of the purpose of a Fellowship (as opposed to a standard grant) is to free the investigator from such demands?

The balance of skills in the team is well suited to the demands of the work programme.

Research Vision

Secondary criterion. Comment on the overall research vision and how the fellowship would enable the applicant to achieve their career aspirations.

The proposal articulates a vision in which `we understand every component of general-purpose higher-level programming languages'. By 'understand', I assume that the proposer means `reason formally about'. Given the breadth of programming languages available today, this is a bold and general vision, and it is certainly one that could guide an entire career. The fellowship should allow the applicant to conduct fundamental work and influence the agenda in programming language semantics globally.

The CfS does not say much about the applicant's career aspirations beyond advancing the state of the art towards the vision outlined.

The host organisation (Oxford) would undoubtedly provide a continually stimulating environment for the fellowship. I was less convinced that the fellowship proposal takes the opportunity to spend extended periods working with other leaders in

the field outside Oxford or the UK. Indeed, I fear that there's a risk the fellowship as described in the CfS will not broaden the proposer's perspective on the field much.

Leadership Potential

Secondary criterion. Given the applicant's declared current career stage, please comment on their potential (and the expected timescale) for them becoming an international research leader.

The assessment criteria for an early career fellowship ask for evidence of leadership, both in terms of maximising the potential of a research team and also potential leadership in the broader community. I am quite convinced that the applicant has the capacity to become a leader in programming language semantics, although I feel the fellowship as proposed may have too much of a focus on running a large project rather than personal development. In the applicant's track record, I could not see the evidence of research team leadership that I would want in order to be confident in the success of a project of this size.

One of the key skills of fellows is the ability to communicate their work to a general audience. The summary in the proforma will only be meaningful to a small audience of cognoscenti. A fellowship could provide the opportunity to gain experience in communicating the motivation, results and fun of our research to a wider audience (an ambassadorial role).

Resources and Management

Secondary criterion. Please comment on the effectiveness of the proposed planning and management and on whether the requested resources are appropriate and have been fully justified. Please comment explicitly on any equipment requested, or the viability of the arrangements described to access equipment needed for this project, and particularly on any university or third party contribution.

The project planning as described in the graphic plan and the Justification of Resources (JoR) is broadly appropriate. I particularly appreciated the discussion of risks in the CfS description of each work package (WP).

I may have missed a discussion on how the dependencies between WPs would be managed. Where the graphic plan shows a dependency of a WP on an Internship (e.g. WP3.1 on I2), is there a plan in place for making progress if the internship should fail? It was not always clear what the nature of the dependency is.

I missed a discussion of how project management would be conducted on a regular basis, including the monitoring of the internships. How often would meetings take place, e.g. with the advisors and collaborators?

Resources Requested:
This is a very substantial fellowship with over 14 person years of effort. The resources are broadly in line with the levels I would expect in a project of that scale.

University or Third Party contribution:
There is a university contribution from both the Department of Computer Science and Balliol College. The department's main contribution is a stimulating intellectual environment, mentoring and career development activities. This is entirely appropriate for the work programme. Balliol will effectively offer a DPhil studentship, although I did not see a discussion in the CfS for how that would be deployed.
Infinitemonekys.ai is a key player in the proposal offering an internship worth £42.5k. Its role is vital to the success of the internship scheme in the proposal. It's an exciting collaboration, but I am a little worried that a lot hinges on this one industry connection persisting through the duration of the fellowship.

Proposal Assessment

Please comment on the extent to which this proposal meets each of the criteria laid out in the call document not already covered by your previous answers.

I believe I have covered most of the assessment criteria for an early career fellowship in the comments above. Some remaining points:

The proposal shows strong scientific quality. The applicant has a very strong early track record and I believe could provide scientific leadership in the future. The applicant's work is being recognised on an international stage.
I am less confident about the evidence of leadership in managing a project team, and of working broadly and across interfaces. The proposal did not demonstrate ambassadorial capacity or experience, although I believe there is definite potential there.

I am confident that the proposed research would be potentially highly valuable, but the proposal did not demonstrate a deep consideration of its relationship to national strategic needs.

I am confident about the quality of the research environment.

The impact aspiration is great, but the proposed actions are largely limited to influencing the programming semantics community with which the proposer is already highly engaged.

The resources are broadly justified, and the project planning is adequate. There is some thinking about risks and contingencies, but I wondered whether the size of the proposed project would detract from the value of its being a fellowship.

The fit to strategic priorities is appropriate.

Overall Assessment

Please summarise your view of this proposal

The proposal is scientifically convincing, original, and timely. There are some areas for improvement in terms of the thoroughness of the impact plan, and broadening the group of industry partners (so the project does not depend too much on one).

If this were a proposal for a large standard grant from a moderately experienced PI, I would be highly supportive. All the same, this is a proposal for a fellowship. The programme of work does not seem to have objectives relating to the fellow or his career and the creation of a platform for future projects. The proposal should really take advantage of the PI-focussed character of fellowships. This might be done via a programme of extended collaborative visits or an opportunity for the fellow to identify and fill skills/knowledge gaps. Ironically, although the proposal speaks of developing "the next two generations of researchers in programming language theory", it seems to be at the expense of the fellow's development.

Under the circumstances, and acknowledging that this could be an excellent standard proposal, I could not strongly support it for a fellowship.

My judgement is that:

1) This proposal is scientifically or technically flawed

2) This proposal does not meet one or more of the assessment criteria

3) This proposal meets all assessment criteria but with clear weaknesses

My confidence level in assessing this is:

4) This is a good proposal that meets all assessment criteria but with minor weaknesses

5) This is a strong proposal that broadly meets all assessment criteria

6) This is a very strong proposal that fully meets all assessment criteria

1	2	✔ 3	4	5	6

Low	Medium	✔ High

Reviewer Expertise

Please indicate your areas of expertise that are relevant to your assessment. Take care not to reveal your identity to the applicant.

Formal methods, software and systems engineering.