Neural Networks Paper Reviews

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Paper ID : Authors' names and paper ID with-held for privacy
Title : : Anti-Windup for time-varying delayed CNNs subject to Input Saturation
Assigned : 06Dec2013
Due : 17Jan2013

For each question, please use the following scale to answer (place an X in the space provided):

RATINGS

1 Superior
2 Good
3 Fair
4 poor
5 Not applicable

Quality of Methodology : 1
Quality of Work : 1
Soundness of Conclusions : 1
Significance of Subject : 1
Clarity : 1
Organization : 1
Priority Rating for Publishing in Neural Networks ("1" is highest) : 1

Is the abstract, and are the figures, legends, and references acceptable? If not please explain:

All of these are very well done.

Please provide a brief and compelling argument supporting (a) your recommendations and (b) the above ratings:

See my comments to the authors.

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This reviewer's personal approach:

nomenclature examples:
p1c1h0.8 = means page 1, column 1 80% of the way down the page (very approximately)
C2. = means Comment section #2 WEAKNESSES (note that actions by the authors are NOT

required for the points)
t_i means variable t with subscript I
t^i means t to the power of I, OR t superscript i (ambiguous, I admit)

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ACTIONS REQUESTED OF THE AUTHORS

I cannot see any really critical corrections or changes to request of the authors.

However, as per my comments in the section “REPRODUCING SELECTED RESULTS” at the end of this review below, I suggest that the authors re-check several results as described there. As I have more confidence in the authors' results than my own, a detailed response by the authors is unnecessary - simply check your results again and let me know that your results are OK, or if corrections have been made as necessary.

In order to conform to the “Neural Networks” journal format :
Citations in the text must be changed throughout the paper, eg “... Chun, Biglou, Lenard, & Kim, 1999 ...”
References at the back of the paper are in the proper format, but should be sorted alphabetically.

NOTE: The points above are the ONLY points that I request that the authors address. From here to the end of the review, there is no requirement for the authors to make any changes to the paper, nor is there a need to respond to me about those points. I provide comments that they may consider at their own discretion, and it is NOT my intention that any of the points below have to be addressed (other than those listed above). I am very afraid that authors feel that they are obliged to answer or make changes, which would waste far too much of their time, and my comments may not even be correct!

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COMMENTS ONLY - actions by the authors are NOT required for the points listed below, to the end of the review. Perhaps some of these comments will be helpful in some way.
(Main paper contributions, positive aspects, observed deficiencies, and suggestions on how to improve them:)

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C1. STRENGTHS OF THE PAPER:

This is a very nice paper, well developed, analyzed, and presented.

ph change to “... ...”

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C2. WEAKNESSES: (again, changes to the paper are not require for these comments)

Nothing to mention.

p4h0.5 It might help to show a form of Equation 8 for x_dot with the control term u, although this is not essential.

P6h0.4 epsilon_T is defined, but epsilon is NOT specifically stated. Even though it is an easy inference, it might be better to be explicit (this is not a requirement, though).

P5h0.? Somewhere in the development of Theorem 2, it might help to repeat the expression of p3h0.8 u = K*x = -R*P1_inv*x from Theorem 1, or its equivalent. I am only saying this because I started on Theorm 2 after a 2 week break, and was fumbling with that (again, this isn't really necessary, but may save time for someone focused on Theorem 2).

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C3. QUESTIONS: (no need to answer)

If the authors have any general comments about novel approaches they have used to develop their “control parameter matrices” (Equations 6, 13, 14), this might be interesting to the reader.

Any comments that the authors may have concerning the optimality of their control might be interesting.

P10h0.75 Figure 8 “... Compared with Fig. 7, one can see that the stability region has been greatly enlarged as expected. ...”
p11h0.6 Figure 11
The authors' results are very impressive, and well illustrated by Figures 8 and 11. It would be interesting to see an overlaid graph by putting Figure 8 results into Figure 11. Figure 8 would appear as a simple point – so to give some idea of the scale of improvement, perhaps there is some way to implement “re-scaled” log-like Figure. Shifting both by adding say 1000, then take the logs – this would produce a very distorted ellipse, but the magnitude of the improvement might be obvious. There is probably a better way.

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C4. DETAILS and GRAMMAR: (again, changes to the paper are not required for these suggestions)

This paper is well written, so I have few suggestions to make. These tend to be stylistic, and may not

be better than the authors' original version, so they should only be considered if to the authors' liking.

p1h0.25 Abstract change to "... handle the saturated terms, we first put forward ..."

p1h0.25 Abstract change to "... delayed system in the absence of input ..."

p1h0.3 Abstract change to "... Lyapunov-Krasovskii theorem. We derive an anti-windup gain matrix to compensate ..."

p1h0.5 References - "... Chua and Yang [1] ..."
These must be changed throughout the paper, along with the list of references, in order to conform to the "Neural Networks" journal format. See comments in my review section "C5. REFERENCES " below.

p1h0.75 change to "... because the physical actuators which ..."

p1h1.0 change to "... research community for it's more aggressive capabilities, and much ..."

p2h0.2 change to "... synchronization problems were considered, research has been rare for CNN-based control for systems with anti-windup arising from state saturation. Considering the wide potential applications of time-delayed cellular neural networks to advanced and high-speed control problems, it is important to study their stability. ..."

p2h0.33 change to "... controller to the system in the absence of input ..."

p2h0.4 change to "... gain control is developed based on the Lyapunov-Krasovskii functional method. ..."

p2h0.4 change to "... Further, the LMI optimization approach is used enlarge ..."

p2h1.0 should explicitly define x_bar even though it may be a convention
eg. x_bar = x(t-tau) or whatever. Same for alpha

p4h0.5 change to "... When inputs saturate, the closed ..."

p4h0.55 change to "... This difference results in a distorted control signal, which finally leads to performance degradation. ..."

p4h0.66 change to "... Hence we choose the windup compensating term Ec (sat1(Kx) ⟆ Kx), and apply it to Equation (8). ..."

p5h0.8 change mis-placed "T" transform symbol for V1 = x_T(t)*P1_inv*x(t)

p8h0.75 change to "... Now, let's apply the windup compensating term ..."
also – use / with

ph change to "... ..."

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C5. REFERENCES (using a quick web search, as opposed to checks using Scopus or standard indexes)
**** Usage of CrossRefs "CrossCheck" via Elsevier's "iThenticate"

C5a) Are references and citations in the standard format for Neural Networks journal? Example : Chun, M., Biglou, J., Lenard, J., & Kim, J. (1999). Using neural networks to predict parameters in the hot working of aluminum alloys. Journal of Materials Processing Technology, vol. 86, pp. 245-251
Notes:
- Italicize the name of the publication (journal).
- Vol(number) can be as "9(10)", for example.
- References should be sorted by the first author's last name.
- Citations in the text are of the form "... Chun, Biglou, Lenard, & Kim, 1999 ..." or "... Chun et al. 1999 ..." (not as reference #'s)

NO - Citations must be changed throughout the paper, eg "... Chun, Biglou, Lenard, & Kim, 1999 ..."
YES - References at the back of the paper are in the proper format, but should be sorted alphabetically. Change these in order to conform to the "Neural Networks" journal format.

C5b) Are references legitimate (using a quick web search and personal familiarity with references)?

As I focused my time on the mathematical developments, I have not checked the references.

C5c) Is this paper significantly different from previous papers by the same authors?

As I focused my time on the mathematical developments, I have not checked the references.

C5d) Is the relevant literature well represented in breadth and Depth?

At a quick glance it appears to be so.

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C6. LIMITATIONS OF THIS REVIEW

As I focused my time on a few mathematical developments, I have not checked :

- although I spent considerable time on the checking of the V1_dot and V2_dot expressions for Theorem 1 only, I did not complete this in time for review submission. This is the greatest weakness of my review.
- p5h0.15 Lemma 1 – I did not check
- I did verify many other steps in the developments, but certainly not all. What I did do, gives me confidence in the authors' work.
- p3h0.4 convex hull theory transform of Equation 4 to Equation 5
- p7&8 results of optimization through Linear matrix inequality (LMI)
- possible errors/ mis-types in Equations 1, 7 (they look OK to me)
- a random selection of references

REPRODUCING SELECTED RESULTS
With respect to my attempts to reproduce the authors' expressions, and my resulting comments under "C3. QUESTIONS: " above, key limitations include :
1. I obtained my results assuming that the '*' in the authors' matrices were zero's, not symmetric reflections
2. My results are similar to the authors', but there are important differences.
3. I have modified my own unvalidated software to do this comparison, so there will be errors in my results.
I should be using well-established, validated toolsets like Isabelle (http://isabelle.in.tum.de/), matlab, mathematica, scilab, OCaml (http://ocaml.org/), etc, etc,
but I need to develop some software anyways so I am modifying/adapting/adding to that for this paper review.
4. I have been lazy in some of the transformations - which will have introduced errors.
5. A detailed response by the authors is unnecessary - simply check the results again and let me know that your results are OK.

Reviewer's expertise on the subject: Low

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THOUGHTS: (again, changes to the paper are not require for these)
Here are some long-winded thoughts that are not really relevant to the paper review per se... For interest only, even if that.
These are separated from the "COMMENTS" above because they are less relevant to the actual paper.

At some time in the future, it would be interesting to see ways to "leverage off" of control systems like this with adaptive+optimizing control systems as illustrated early on by the Approximate Dynamic Programming community, and as formalised by Frank Lewis' group in a "unifying mathematical jargon" recognizable by both the adaptive and the optimal control communities.

For example, what happens as devices/systems age and the environment changes (actuators wear, systems are pushed to the limit when non-linearities strengthen, etc.

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CONFIDENTIAL COMMENTS for review chair / committee use only:

None other than the list of Ratings

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REPRODUCING SELECTED RESULTS

The authors are free to ignore this section altogether and not make any changes arising from it, but it would help having a confirmation that they have double-checked their results, and have no need for changes.

The intent of this section is to provide an uindependent double-check for the authors, which may or may not be useful.

It amy be necessary to copy this section to a text editor and use small font sizes, in order to see the tables properly.

```
++---------------------------++
Theorem 1, Lyapunov_Krasovskii_limit


     Lyapunov_Krasovskii_core
+-------------------------------------------+-----------------+
|He(P1_inv*(A+A1*D(r_i))-B*R*P1_inv)+P1_inv   |P1_inv*C*D(r_j)  |
+-------------------------------------------+-----------------+
|0                                          |-(1-beta)*P1_inv |
+-------------------------------------------+-----------------+


Reviewer's expression
Lyapunov_Krasovskii_limit
(+ x_T * (+ He{P1_inv*(A+A1*D@[r_i])}*x
          + P1_inv*C*D@[r_j]*x_bar
          - P1_inv*B*R*x
          + P1_inv*x
         )
 - (1-beta)x_bar_T*P1_inv*x_bar
)



 Lyapunov_Krasovskii expression using epsilon -> Authors' results for comparison p4h.05 substituting
for u(t)  :
V_dot = V1_dot + V2_dot  <=   ss lambda_i mu_j *
(x_T * (  He{P1_inv*(A+A1*D(r_i))}x
        + 2P1_invCD(r_j)x_bar
        - 2P1_inv*BRP1_invx
        + P1_inv*x
       )
 - (1-beta)x_bar_T*P1_inv*x_bar
)
```

```
The results for the Lyapunov_Krasovskii_limit are the same EXCEPT for the terms :
Reviwer's results              B*R*P1_inv*x
Authors' results               2P1_inv*B*R*P1_inv*x
and also for the factor of 2 in front of the Author's results expression :  2P1_invCD(r_j)x_bar
```

```
++--------------------------++
Theorem 1 proof - Check of the control_parameters times P1_inv diagonal matrix
```

authors_control_parameters

((He{(A + A1*D@[r_i])*P1 - B*R} + P1))	C*D@[r_j]*P1
0	- (1-beta)*P1

Reviewer's control_parameter_limit_final_compact

He{P1_inv*(A+A1*D@[r_i]) - B*R*(P1_inv^2)} + P1_inv	C*D@[r_j]*P1_inv
0	-(1-beta)*P1_inv

control_parameter_limit_authors (CPLA)

He{P1_inv*(A+A1*D@[r_i]) - B*R*P1_inv} + P1_inv	P1_inv*C*D@[r_j]
transpose(P1_inv*C*D@[r_j])	-(1-beta)*P1_inv

```
7. My comments on results, and my next attempts or comments/corrections for authors
1. control_parameter_limit_authors@[0,0] -> I have B*R*(P1_inv^2) instead of B*R*P1_inv
2. control_parameter_limit_authors@[0,0] -> I have 0 instead of transpose(P1_inv*C*D@[r_j])
```

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++--------------------------++
Theorem 2, Lyapunov_Krasovskii_limit
```

epsilon2_sym

x	x_bar	phi(Kx)

epsilon2_T_sym

x_T
x_bar_T
phi_T(Kx)

Lyapunov_Krasovskii_core2

```
+----------------------------------------+---------------+-------------------
```

```
|(( He{P_inv*(A_bar+A1*D@[r_i])} + P_inv ))|P_inv*C*D@[r_j]|P_inv*(H_T*T_inv-B-
+-----------------------------------------+---------------+-------------------
|0                                        |-(1-beta)*P_inv|0
+-----------------------------------------+---------------+-------------------
|0                                        |0              |-2*T_inv
+-----------------------------------------+---------------+-------------------

----+
E_c)|
----+
    |
----+
    |
----+
```

```
My result from epsilon matrix multiplication (Lyapunov_Krasovskii_limit2)
1. x_T *
2.     (+ P_inv*(( He{(A_bar+A1*D@[r_i])}*x + C*D@[r_j]*x_bar + (H_T*T_inv-B-E_c)*phi(Kx) ))
       )
3.      + x_T*P_inv*x
4.      - (1-beta)*x_bar_T*P_inv*x_bar
5.      - 2*phi(Kx)*T_inv*H*P_inv*x

Authors' target expression :
1. x_T  *
2.     (+ P_inv*(( He{(A_bar+A1*D(r_i))*x + 2*C*D@[r_j]*x_bar - 2*(B+E_c)*phi(Kx)} ))
3.      + x_T*P_inv*x
4.      - (1-beta)*x_bar_T*P_inv*x_bar
5.      - 2*phi_T(Kx)*T_inv*(phi(Kx)-H*P_inv*x)
       )

Comparison by line (mine first, authors next) :
1. Lines 3, 4, are the same for myself and the authors
2. In my result, x_T only multiplies line 2, not the others.  For the authors, x_T multiplies
everything.
3. In line 2,  I have an extra term H_T*T_inv (the authors have NO H_T!), and the authors have an extra
factor of 2
4. In line 5, the authors have an extra term phi(Kx)



++---------------------------++
Theorem 2, authors' parameter matrix - Check of the pre-and-post multiplying by P_inv-T_inv diagonal
matrix


     authors_control_parameters2
+------------------------+-----------+---------+
|He((A_bar+A1*D@[r_i])*P)|C*D@[r_j]*P|H_T-B*T-F|
+------------------------+-----------+---------+
|0                       |-(1-beta)*P|0        |
+------------------------+-----------+---------+
|0                       |0          |-2*T     |
+------------------------+-----------+---------+

     control_parameter_multiple2
+------+------+-----+
|P1_inv|0     |0    |
+------+------+-----+
|0     |P1_inv|0    |
+------+------+-----+
|0     |0     |T_inv|
+------+------+-----+
```

reviewer's control_parameter_limit2_final_compact

He{(A_bar+A1*D@[r_i])}*P1_inv	P1_inv*C*D@[r_j]	P1_inv*(H_T*T_inv-B-E_c)
0	-(1-beta)*P1_inv	0
0	0	-2*T_inv

control_parameter_limit2_authors

((He{P_inv*(A_bar+A1*D@[r_i])} + P_inv))	P_inv*C*D@[r_j]	P_inv*(H_T*T_inv-B-
0	-(1-beta)*P_inv	0
0	0	-2*T_inv

E_c)

Comparison of my results to to equivalently-formated target expression :
control_parameter_limit2_authors versus control_parameter_limit2_final_compact

The results are very similar, with the only notable difference being cell [0,0] :
1. authors He{P_inv*(A_bar+A1*D@[r_i])} + P_inv
2. reviewer He{(A_bar+A1*D@[r_i])}*P1_inv

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